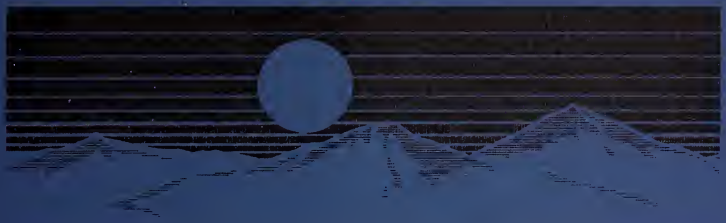
S
628.1686
M26phe
1989
Public health and environmental assessment data summary report, Rocker and Ramsay areas, Silver Bow Creek CERCLA site,

SILVER BOW CREEK INVESTIGATION

FINAL

PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT DATA SUMMARY REPORT ROCKER AND RAMSAY AREAS SILVER BOW CREEK CERCLA SITE, MONTANA



SITE RESEARCH COLLECTION

CH2M HILL

MONTANA STATE LIBRARY
S 628.1686 M26phe 1989 c.1
Public health and environmental assessme
3 0864 00065277 9

FINAL

PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

DATA SUMMARY REPORT

ROCKER AND RAMSAY AREAS

SILVER BOW CREEK CERCLA SITE, MONTANA

EPA REGION VIII

Prepared for:

Montana Department of Health and Environmental Sciences
Helena, Montana

Prepared by:

CH2M HILL, Inc.
Helena, Montana

Chen-Northern, Inc.
Helena, Montana

April 28, 1989

Document No. SBC-PHEA-F-RO-042889

Copy 14 of 35

MAY 4 - 1994

EXECUTIVE SUMMARY

This report presents and summarizes environmental data collected during the summer of 1988 in and near the towns of Rocker and Ramsay, Montana, in conjunction with the Public Health and Environmental Assessment (PHEA) of the Silver Bow Creek CERCLA site. Tasks completed during this investigation included sampling of soils and groundwater and completion of a literature review to collate data and information regarding concentrations of metals in soils, surface water, and groundwater at sites geologically similar to the Silver Bow Creek CERCLA site.

Data produced during this investigation supplement data generated during the Phase I Remedial Investigation at the Silver Bow Creek CERCLA site reported by MultiTech (1987). Objectives of sampling completed for this study were to supply data that are needed to complete a PHEA for the Silver Bow Creek site. These additional data needs included:

- Preliminary characterization of surface soil metal concentrations in residential areas in the middle portions of the Silver Bow Creek CERCLA site;
- Additional characterization of groundwater chemistry in the Silver Bow Creek alluvial aquifer; and,
- Collation of literature germane to evaluating metal concentrations in various environmental media at the Silver Bow Creek CERCLA site

Work tasks completed to address these needed data included the following:

- Completion of a X-ray fluorescence (XRF) survey of surface soils in and adjacent to the Rocker and Ramsay areas;

- o Collection of 23 soil samples for laboratory determination of total metals parameters;

- o Collection and analysis of groundwater samples from four monitoring wells completed in the Silver Bow Creek alluvial aquifer; and,

- o Collation and compilation of data contained in the scientific literature to provide a means of assessing previous and present concentrations of metal analytes in soil, surface water, and groundwater

Data collected indicate metal concentrations in soils in the residential areas of Rocker and Ramsay are variable. Locations of sample sites exhibiting highest metal concentrations generally coincided with the presence of obvious tailings material or mineralized waste rock. Other elevated metals concentrations in soils were measured in areas that were likely contaminated by local residents by use of insecticides, paints, or other chemicals. In general, soils in areas near Silver Bow Creek contained higher levels of metals when compared to soils located out of the Silver Bow Creek flood plain.

Analyses of groundwater samples collected during this study were similar to analyses of samples collected from the same wells during the Phase I RI. The complete analyses of groundwater chemistry for these wells are contained herein.

The literature review produced data that may be usable for comparative purposes in attempting to establish pre-mining concentrations of metals in soils, surface water, and groundwater at the Silver Bow Creek CERCLA site. Data were sought from areas which are geologically similar to the Silver Bow Creek CERCLA site but which are relatively undisturbed by man's activities. Information collected is grouped by those data reflective of regional, local, and locally mineralized areas.

Sampling and laboratory methodologies of investigators included in the literature review varied. Resultant ranges of concentrations of metal parameters in the various environmental media were, however, relatively narrow. In general, information derived from the various studies included in the literature review produced data reflective of the range of pre-mining concentrations present in the Silver Bow Creek CERCLA study area.

Digitized by the Internet Archive
in 2015

https://archive.org/details/publichealthenvi1989chen

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	i
LIST OF FIGURES	v
LIST OF TABLES	vii
LIST OF APPENDICES	ix
1.0 INTRODUCTION	1
1.1 SITE AND PROJECT BACKGROUND	1
1.2 PROJECT OBJECTIVES	4
2.0 SOILS INVESTIGATION	7
2.1 X-RAY FLUORESCENCE SOILS SCREENING	7
2.1.1 Methods	7
2.1.2 Changes to the Project Work Plan	8
2.1.3 Presentation of Data	9
2.2 SOIL SAMPLING	15
2.2.1 Methods	15
2.2.2 Changes to the Project Work Plan	16
2.2.3 Presentation of Data	16
3.0 GROUNDWATER INVESTIGATION	26
3.1 METHODS	26
3.2 CHANGES TO THE PROJECT WORK PLAN	26
3.3 PRESENTATION OF DATA	26
4.0 ENVIRONMENTAL MEDIA LITERATURE REVIEW	32
4.1 METHODS	32
4.2 SOILS	33
4.3 SURFACE WATER DATA	41
4.4 GROUNDWATER DATA	47
5.0 DATA VALIDATION	50
5.1 INTRODUCTION	50
5.2 CONTRACT COMPLIANCE SCREENING	50
5.3 DATA VALIDATION, REDUCTION, AND QUALITY ASSURANCE STATEMENTS	52
5.3.1 Accuracy	52
5.3.2 Precision	53
5.3.3 Representativeness	53
5.3.4 Completeness	55
5.3.5 Comparability	55
5.4 SUMMARY QUALITY ASSURANCE STATEMENTS	55
5.5 QUALITY CONTROL OF FIELD MEASUREMENTS	58
6.0 BIBLIOGRAPHY	59

LIST OF FIGURES

Number		Page
1-1	Silver Bow Creek CERCLA Site Index Map	2
1-2	Location of Study Area for Public Health and Environmental Assessment Data Collection Activities; Silver Bow Creek CERCLA	3
2-1	XRF Soil Screening/Sampling Locations; Rocker Area; Silver Bow Creek CERCLA PHEA	10
2-2	XRF Soil Screening/Sampling Locations; Rocker Townsite; Silver Bow Creek CERCLA PHEA	11
2-3	XRF Soil Screening/Sampling Locations; Ramsay Area; Silver Bow Creek CERCLA PHEA	12
2-4	XRF Soil Screening/Sampling Locations; Ramsay Townsite; Silver Bow Creek CERCLA PHEA	13
2-5	XRF Soil Screening/Sampling Locations; Miles Crossing Area; Silver Bow Creek CERCLA PHEA	14
2-6	Laboratory-Determined Concentrations of As, Cd, Ni, and Cr; Rocker Area; Silver Bow Creek CERCLA PHEA	18
2-7	Laboratory-Determined Concentrations of As, Cd, Ni, and Cr: Rocker Townsite; Silver Bow Creek CERCLA PHEA	19
2-8	Laboratory-Determined Concentrations of As, Cd, Ni, and Cr; Ramsay Area; Silver Bow Creek CERCLA PHEA	20
2-9	Laboratory-Determined Concentrations of As, Cd, Ni, and Cr; Ramsay Townsite; Silver Bow Creek CERCLA PHEA	21
2-10	Laboratory-Determined Concentrations of As, Cd, Ni, and Cr; Miles Crossing Area; Silver Bow Creek CERCLA PHEA	22
3-1	Monitoring Well Locations; Silver Bow Creek CERCLA Public Health and Environmental Assessment	27

LIST OF FIGURES
(continued)

Number		Page
4-1	Study Area Locations for Cited References of Rock, Soil, and Stream Sediment Data, Montana	35
4-2	Literature Review Surface Water Locations: Boulder Batholith Area	42
4-3	Literature Review Well Locations: Boulder Batholith Area	48

LIST OF TABLES

Number		Page
2-1	Soils Parameter List; Silver Bow Creek CERCLA Public Health and Environmental Assessment	17
2-2	Statistical Summary of Soil Parameters; Silver Bow Creek CERCLA Public Health and Environmental Assessment	23
2-3	Soil Metals Concentrations Exceeding 100% of the Geometric Mean, Silver Bow Creek CERCLA Public Health and Environmental Assessment	24
3-1	Groundwater Parameter List; Silver Bow Creek CERCLA Public Health and Environmental Assessment	28
3-2	Summary of Groundwater Data from Monitoring Wells TS-01, GS-01, GS-03, and GS-06; Silver Bow Creek CERCLA PHEA	29
3-3	Statistical Summary of Groundwater Quality Parameters; Silver Bow Creek CERCLA PHEA	30
4-1	Soil Metals Analyses, Regional and Local Compilations; Silver Bow Creek CERCLA Site, Public Health and Environmental Assessment	36
4-2	Bedrock Metals Analyses, Regional and Local Compilations; Silver Bow Creek CERCLA Site, Public Health and Environmental Assessment	37
4-3	Stream Sediment Analyses, Regional and Local Compilations; Silver Bow Creek CERCLA Site, Public Health and Environmental Assessment	38
4-4	Ranges of Soil Metals Concentrations (mg/kg); Silver Bow Creek CERCLA, Public Health and Environmental Assessment, Rocker and Ramsay Areas	40
4-5	Surface Water Quality Data from Literature Review, Various Local and Regional Studies; Silver Bow Creek CERCLA Site, Public Health and Environmental Assessment	43
4-6	Summary of Surface Water and Groundwater Metals Concentration Ranges (ug/L) Silver Bow Creek CERCLA, Public Health and Environmental Assessment	45

LIST OF TABLES
(continued)

Number		Page
4-7	Groundwater Quality Data from Literature, Silver Bow Creek CERCLA Site, Montana, Public Health and Environmental Assessment	49
5-1	Quality Assurance Statements for Soil Samples Collected August 3-5, 1988. Rocker/Ramsay (Rocker-Miles Crossing). Silver Bow Creek. Case No. 10181	56
5-2	Quality Assurance Statements for Water Samples Collected August 3-19, 1988. Rocker/Ramsay (Rocker-Miles Crossing). Silver Bow Creek. Case No. 10204	57

LIST OF APPENDICES

A -- X-ray Fluorescence Index Values

B -- XRF Soil Screening and Soil Sampling Sites, Site Location and Description Information

C -- Soils Laboratory Analytical Data Base

D -- Groundwater Quality Data Base

E -- Descriptions of Selected Studies Included in Literature Review

F -- QA/QC Report Forms

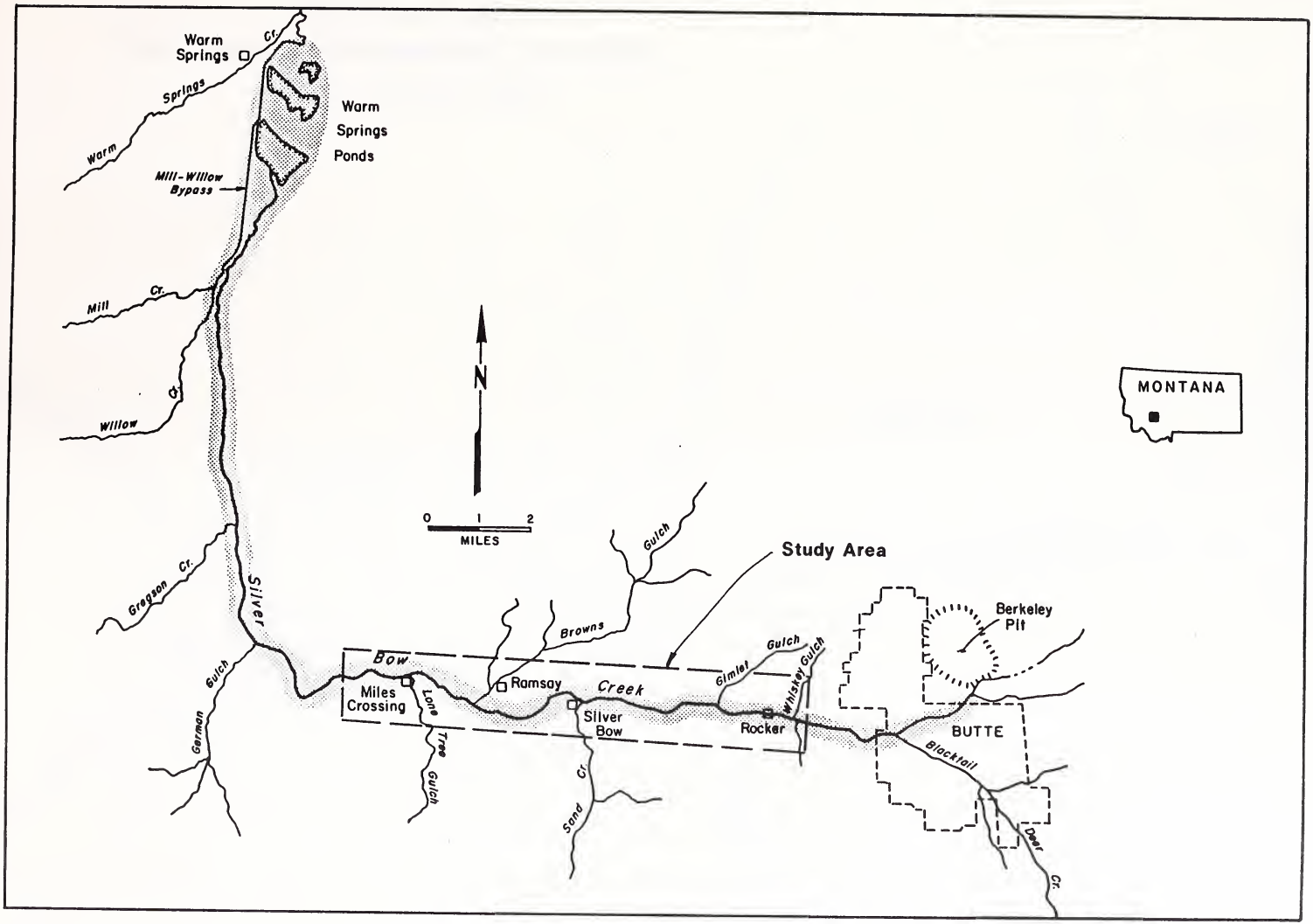
1.0 INTRODUCTION

This report presents and summarizes environmental data collected to support completion of a site-wide Public Health and Environmental Assessment (PHEA) for the Silver Bow Creek CERCLA site, Montana (Figure 1-1). Field activities were conducted in two distinct areas of the Silver Bow Creek CERCLA site, the Rocker area and the Ramsay/Miles Crossing area (Figure 1-2). This report also summarizes findings of a literature review completed to identify previous and current concentrations of various elements in soils, surface water, and groundwater at locations geologically similar to the Silver Bow Creek CERCLA site.

Tasks completed during this study were performed in accordance with a scope of work described in Technical Memorandum II, Evaluation of Data Needs, Site-Wide Public Health and Environmental Assessment, Silver Bow Creek CERCLA Site (CH2M HILL, 1987). Field work was completed in accordance with the project sampling and analysis plan (CH2M HILL, 1988a). This report is organized by work tasks completed during the project. Deviations from the project work plan tasks are also described herein. Data summaries and preliminary interpretations of the data are presented in the text; resultant data bases and supporting information are contained in appendices to this report.

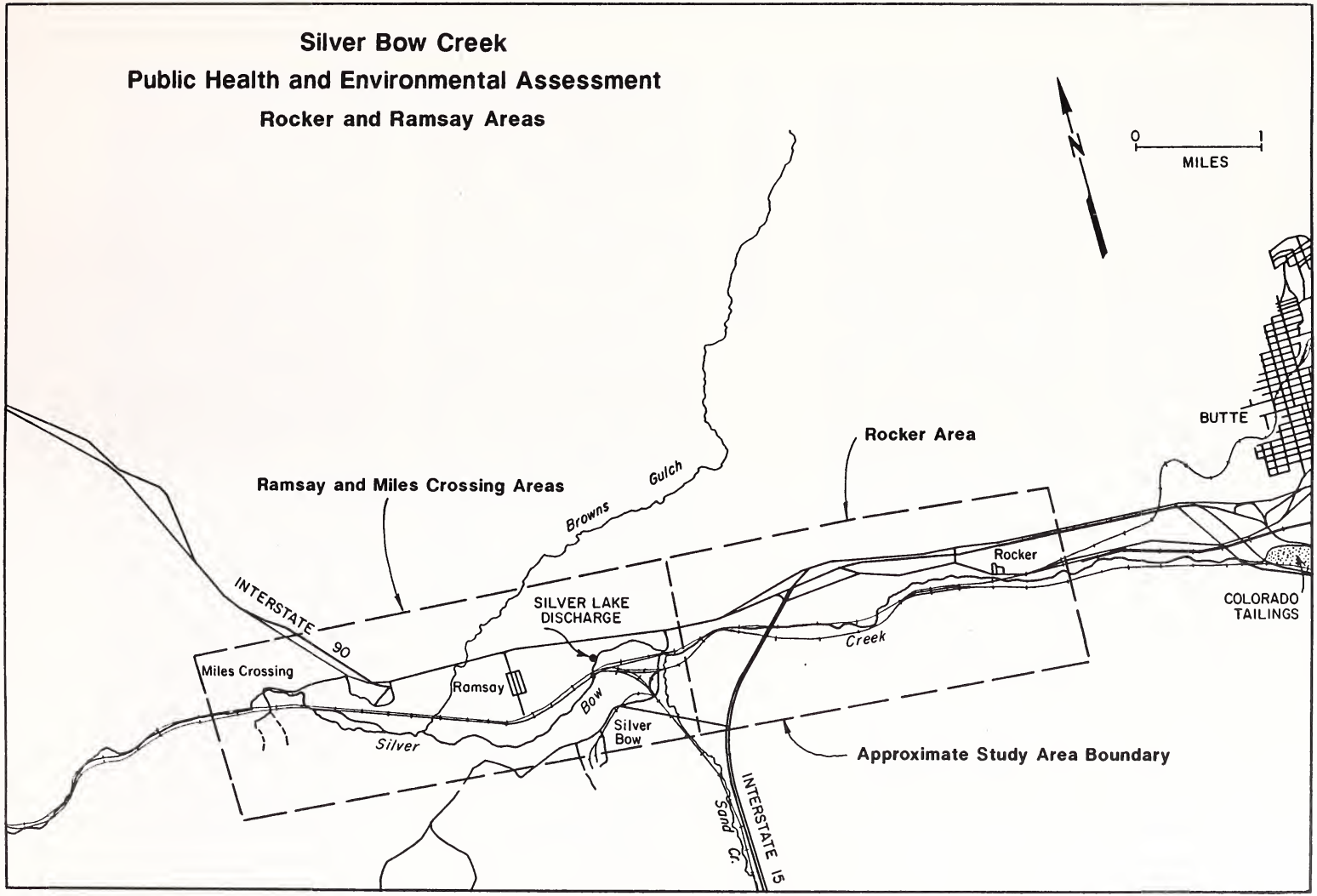
1.1 SITE AND PROJECT BACKGROUND

When the Silver Bow Creek CERCLA site was placed on the National Priorities List (NPL) in September 1983, the site boundaries extended from Butte downstream to Deer Lodge, Montana. In November 1985, the boundaries of the site were expanded to include the Butte Addition. In early 1986, the site boundaries were expanded westward from Deer Lodge to the Milltown Reservoir. The Solid and Hazardous Waste Bureau of the Montana Department of Health and Environmental Sciences (MDHES) administers and directs the



Silver Bow Creek CERCLA Site Index Map

FIGURE 1-1



Location of Study Area for PHEA Data Collection Activities

FIGURE 1-2

efforts to conduct remedial investigation/feasibility study (RI/FS) activities associated with the majority of the site. However, EPA in consultation with MDHES, directs the efforts to conduct the RI/FS activities at the Butte Addition.

The portion of the site under investigation by MDHES (Figure 1-1) includes the Metro Storm Drain, Silver Bow Creek the Clark Fork River areas adjacent to these surface water bodies. The Silver Bow Creek CERCLA site is an extremely large and complex area impacted by mining and mill wastes remaining from over 100 years of mining activity in the Butte area. These activities have changed the area's environment substantially. Currently, the site is being studied to determine methods to clean up areas of contamination that exist within its 200 square miles.

1.2 PROJECT OBJECTIVES

The primary objective of this study was to collect additional data to fulfill data needs identified in Technical Memorandum II, Evaluation of Data Needs, Site-Wide Public Health and Environmental Assessment, Silver Bow Creek CERCLA Site (CH2M Hill, 1987). This document evaluated available soils, surface water, and groundwater data for each Feasibility Study Unit (FSU) within the Silver Bow Creek CERCLA site as to the utility of these data for completing a FSU-specific and a site-wide public health and environmental assessment (PHEA). As a result of this evaluation, certain data gaps were identified to support such an assessment.

Feasibility study units I-1 and I-2 encompass the area within and near the city limits of Butte along the Metro Storm Drain and along Silver Bow Creek to below the Colorado Tailings. Two ongoing soil studies in the residential areas along the Metro Storm Drain and existing tailings material data were determined adequate to provide necessary soils data for the PHEA. Feasibility study units II-1, II-2, and the Rocker FSU include the area within one mile on either side of Silver Bow Creek from downstream of the Colorado Tailings to the head of the canyon near the middle reaches of Silver Bow Creek. Soils data available for this area were limited to a

few samples collected during the Phase I RI. Additional soil samples were determined to be necessary to complete the PHEA in these areas. Areas targeted for collection of additional soils data in these FSUs included residential areas near Rocker and Ramsay. The purpose of the proposed sampling was to evaluate the possible presence of wind deposited tailings material in these residential areas and associated risks to the residents.

Feasibility study units III-1 and III-2 include the sparsely populated canyon area along Silver Bow Creek from Miles Crossing to Gregson and from Gregson to the Warm Springs Ponds, respectively. No additional soils data were deemed necessary in FSU III-1 because of the lack of residences within the area. Soil samples were collected in FSU III-2 during the Phase I RI and no additional data were determined to be necessary for the PHEA. FSU-IV includes the Warm Springs Ponds. Additional soil samples were collected during the Phase II RI for this area and no additional soils data were determined to be necessary.

Surface water and sediment data available for the site were also reviewed for adequacy to perform a site-wide PHEA for the Silver Bow Creek CERCLA site. Additional spring runoff data during high flows were determined to be necessary at FSU I-1 and the Rocker FSU; however, spring runoff in 1988 was of insufficient magnitude to justify collection of additional samples at that time. It was determined that additional runoff data would be best collected on a FSU-specific basis. Additional surface water quality data were determined to be necessary at the Warm Springs Ponds (FSU IV). These data were collected as part of the Phase II RI for this area.

Groundwater data from domestic and monitoring wells were obtained during the Phase I RI from throughout the study area. Parameters analyzed during the Phase I RI were determined to be incomplete for purposes of the PHEA. Data needs identified included collection of samples from the shallow alluvial aquifer along Silver Bow Creek for a more complete chemical analysis, including common anions and cations. Three shallow monitoring wells, located between Rocker and Miles Crossing and completed in Silver Bow Creek alluvium, were selected for this purpose.

It was determined that no additional air quality data were necessary at this time. Additional data may need to be obtained if residential soil sampling indicates high concentrations of contaminants.

Additional information necessary to prepare a PHEA on the Silver Bow Creek site include the approximate concentrations of metals in soil, surface water, stream sediments, and groundwater in the area prior to mining activities. This issue was to be addressed initially by completion of a literature review of geologically similar sites that have not been mined or for which environmental data are available prior to mining activities. The results of this literature review are presented in this report.

Tasks completed during this study included: (1) an X-ray fluorescence (XRF) soils screening survey; (2) soils sampling for laboratory analysis of inorganic parameters in and adjacent to the individual residential areas of Rocker and Ramsay; (3) evaluation of existing groundwater quality data; (4) collection of groundwater samples from the alluvial aquifer along Silver Bow Creek between Ramsay and Miles Crossing; and (5) completion of a literature review to determine natural ranges of concentrations of inorganic parameters in soils, surface water, and groundwater at sites geologically similar to the Silver Bow Creek site, but which are relatively undisturbed by man's activities.

Data generated or collected in this study include: (1) XRF index values for 161 soil samples collected primarily from the residential areas at the Rocker and Ramsay locations; (2) laboratory metal analyses for 22 soil samples collected from selected XRF screening locations; (3) groundwater metal analyses for four samples; and (4) soils, surface water, and groundwater analytical data from various published and unpublished reports.

2.0 SOILS INVESTIGATION

The soils investigation completed in the Rocker and Ramsay/Miles Crossing areas consisted of two components: a screening study using an X-ray fluorescence spectrometer (XRF), and soil sampling for laboratory determinations of metals parameters. Each of these components is discussed in the sections that follow.

2.1 X-RAY FLUORESCENCE SOIL SCREENING

2.1.1 Methods

An X-ray fluorescence (XRF) screening survey of soils in the study area (Figure 1-2) was completed during August 1988, with an ATX-100 portable X-ray fluorescence spectrometer (XRF) manufactured by Aurora Tech, Inc., Salt Lake City, Utah. XRF soil screening sample sites were located in accordance with the project sampling and analysis plan (CH2M HILL, 1988a). Sample sites were concentrated in residential areas of the Rocker and Ramsay communities; several sample sites were also located in outlying areas to provide greater areal distribution of sample sites and to provide additional information on the relative concentrations of soil metals in these outlying areas.

Soil samples for XRF screening were collected from the upper one inch of the soil profile in accordance with procedures described in the project sampling and analysis plan (CH2M HILL, 1988a). Collected soil samples were exposed to the Cd-109 and Fe-55 sources in the XRF instrument. Index and count values for elements derived from both sources were uploaded into a portable computer in the field. The XRF instrument was calibrated in accordance with the project Sampling and Analysis Plan (CH2M Hill, 1988a) prior to use each day.

XRF index values obtained from soil samples are generally related to concentrations of specific elements in individual soil samples. Theoretically, the higher the index value, the higher the actual concentration of the element in the soil. However, numerous other factors (e.g. grain size, moisture content, element concentration) can influence the index value obtained from a sample.

The XRF was used in the screening phase of this investigation to provide a general indication of the relative concentrations of metals in soils within the study area. Data generated during the XRF survey were used to locate soil sample sites for laboratory analysis which would provide the data user with a range metals concentrations found in the area. Areas for which similar metals concentrations were indicated by XRF index values were delineated, and this information was used to locate soil sample sites which would adequately characterize the site with a minimum number of samples submitted for laboratory analysis.

Because of numerous variables which affect the accuracy of XRF data, the extrapolation of XRF data generated during this study to predict actual element concentrations in soils is not considered a valid use of the data. A complete analysis of the soil collection methods, soil grain size, soil moisture, XRF index values, and laboratory determined element concentrations would be necessary to determine the validity of correlations between XRF generated values and laboratory concentrations. This type of analysis is beyond the scope of this data summary report.

2.1.2 Changes to the Project Work Plan

No changes to the project sampling and analysis plan (CH2M Hill, 1988a) were implemented during completion of the XRF soil screening study.

2.1.3 Presentation of Data

Locations of XRF screening sample sites are shown on Figures 2-1 through 2-5. Resultant index value data for selected elements measured are contained in Appendix A. Descriptions of soil types at each XRF soil screening location and other information regarding the screening sites are contained in Appendix B. Soil screening locations are labeled with an RSS prefix in Appendices A and B. All prefixes are omitted from figures showing soil screening locations for simplicity.

Several XRF screening sample sites exhibited anomalously high index values for certain elements as compared to index values measured at other sample sites in the area. Some of these high readings were obtained from sites characterized by obvious waste rock and/or tailings material or from sites located proximal to known contaminated areas such as the historic Rocker Timber Treatment site (Figure 2-2). Several other anomalies in index values were likely caused by activities of the local residents or were possibly due to the presence of structures on the property. A brief description of sites exhibiting anomalously high index values follows.

- Site RSS-008A and RSS-008D (Figure 2-2, Sites 8A and 8D): These sites were within 10 feet of each other and exhibited XRF index values for arsenic, lead, mercury and selenium 50 percent greater than adjacent screening sites RSS-008B, RSS-008C, RSS-008E, RSS-008F, RSS-008G, RSS-009A, RSS-009B, RSS-009B, and RSS-009C. Conversations with the owners of this property indicated that metal waste drums were stored in the area and various types of ant poison had recently been used at this location.

- Site RSS-028B (Figure 2-4, 28B): The soil sample collected for XRF screening at this site was obtained near the downspout of a roof gutter. The sample contained sand apparently derived from the asphalt shingles on the roof and paint flakes, possibly originating from the house. XRF index values for arsenic,

EXPLANATION

- XRF LOCATION
- GW AND SOIL SAMPLING LOCATION

20B
20C
20A
21C
21A
21B
19C
19A
19B
22A
22C
22B
15A
15B
47A
ROCKER TOWNSITE
1B
1A
5A
3A
1E
5C
7A
11A
14B
11B
14E
SEE FIGURE 2-2 FOR DETAIL
13B
13C
13A
18A
18B
18A
18C
16B
17D
17C
17B
17A

XRF SOIL SCREENING/SAMPLING LOCATIONS
SBC CERCLA PHEA

FIGURE 2-1
ROCKER AREA

XRF SOIL SCREENING/SAMPLING LOCATIONS
SBC CERCLA PHEA

FIGURE 2–2
ROCKER TOWNSITE

EXPLANATION

- XRF LOCATION
- XRF AND SOIL SAMPLING LOCATION

N

0 1000
Approx. Feet

DAWSON

SEE FIGURE 2-4 FOR DETAIL

RAMSAY TOWNSITE

SILVER BOW

SILVER BOW CREEK

XRF SOIL SCREENING/SAMPLING LOCATIONS
SBC CERCLA PHEA

FIGURE 2-3
RAMSAY AREA

EXPLANATION

- XRF LOCATION
- XRF AND SOIL SAMPLING LOCATION

RAMSAY SCHOOL

44B
44A
46A
33C
33B
33A
45A
32A
23B
23A
23C
32B
24B
24A
31B
31A
32C
31C
45B
30B
30A
30C
25B
25A
45C
41B
38D
41A
38C
41C
26B
26A
26E
26C
26D
38B
38A
29C
29B
29E
29A
29D
39A
39B
28C
28B
28D
28A
39D
39C
27C
39E
40C
27A
27B
40A
40B
42A
43A

N

0 200
Approx. Feet

XRF SOIL SCREENING/SAMPLING LOCATIONS
SBC CERCLA PHEA

FIGURE 2–4
RAMSAY TOWNSITE

FIGURE 2-5 MILES CROSSING AREA
XRF SOIL SCREENING/SAMPLING LOCATIONS
SBC CERCLA PHEA

copper, mercury, nickel, selenium, and zinc were 50 percent greater at this location than adjacent screening sites RSS-027A, RSS-027B, RSS-028A, RSS-028C, and RSS-028D.

- Site RSS-048B (Figure 2-2, 48B): This site was located on the south bank of Silver Bow Creek near the historic Rocker Timber Treatment site. XRF index values for arsenic, copper, chromium, iron, lead, manganese, mercury, nickel, selenium, and zinc were greater than 100 percent higher than adjacent screening sites RSS-005C, RSS-014A, RSS-014B, RSS-014C, and RSS-048A. High index values measured at this location may represent contamination from the historic timber treatment site.

2.2 SOIL SAMPLING

2.2.1 Methods

XRF data derived from the soils screening investigation were evaluated to locate sites for collection of samples for laboratory analysis. Soil sample locations selected were those which encompassed a range of XRF index values for copper, zinc, arsenic, and lead. Soil samples were labeled with an SBC-SO prefix to correspond to the project Sampling and Analysis Plan (CH2M Hill, 1988a). The numerical portion of the site location identifier is the same as that designated during the XRF screening portion of this study (designated with an RSS prefix). All prefixes are omitted from figures showing soil screening and sampling locations for simplicity.

Soil samples were collected from the upper one inch of soil at each sampling location in accordance with procedures described in the project sampling and analysis plan (CH2M HILL, 1988a). Collected samples were screened through a No. 10 sieve (2 mm); material not passing through the sieve was discarded. Collected samples were placed in one-liter I-CHEM

glass jars and shipped to an EPA contract laboratory for analysis of parameters listed in Table 2-1. QA/QC procedures and data validation methods were completed in accordance with the project sampling and analysis plan (CH2M HILL, 1988a).

XRF count and index values were also obtained from each of the soil samples collected for laboratory analysis prior to shipment. These data allowed verification of XRF index values obtained during the screening phase of this study.

2.2.2 Changes to the Project Work Plan

No changes to the project sampling and analysis plan (CH2M Hill, 1988a) were implemented during completion of the soil sampling task.

2.2.3 Presentation of Data

Figures 2-1 through 2-5 show locations of sampling sites from which samples were collected for laboratory analysis. Analytical results of the soil samples are presented in Appendix C. Spatial plots of arsenic, cadmium, chromium, and nickel concentrations are presented in Figures 2-6 through 2-10. Statistical summaries of analytical data including minimum, maximum, mean, and standard deviation are contained in Table 2-2. Sample site RSS-SO-008A was omitted from the statistical calculations due to extremely high concentrations of arsenic, cadmium, and selenium. Possible sources of these high concentrations at this site were discussed in Section 2.1.2.

Samples which contained metals concentrations greater than 100 percent of the geometric mean of the 22 samples analyzed by the laboratory are listed in Table 2-3. A brief description of these sites is presented in Appendix B. Sources of elevated metals at many of the sample sites identified in Table 2-3 could not be accurately identified. Several of the samples,

TABLE 2-1

SOILS PARAMETER LIST;
SILVER BOW CREEK CERCLA
PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT
ROCKER AND RAMSAY AREAS

Aluminum

Antimony

Arsenic

Barium

Beryllium

Cadmium

Calcium

Chromium

Cobalt

Copper

Iron

Lead

Magnesium

Manganese

Mercury

Nickel

Potassium

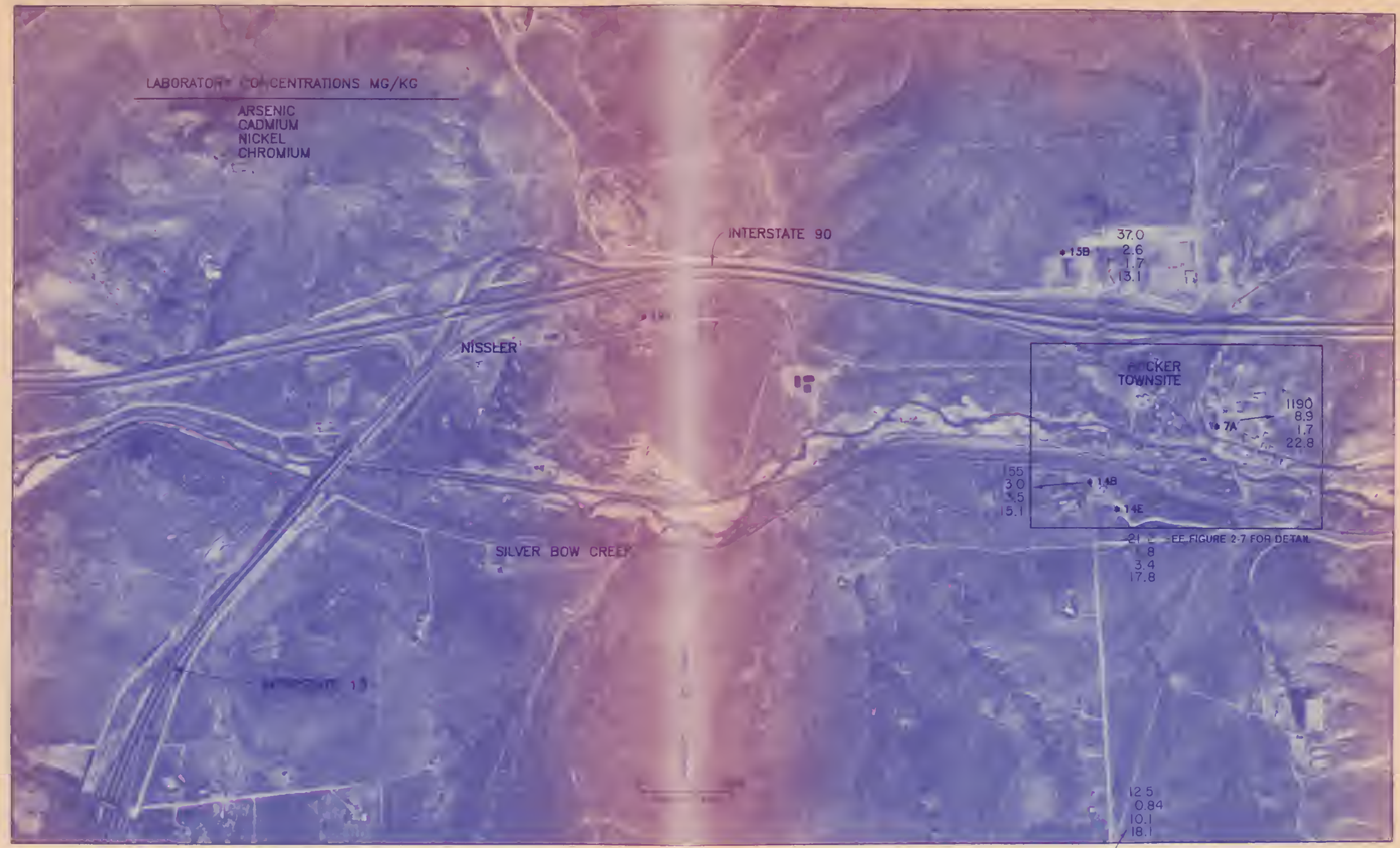
Selenium

Silver

Thallium

Vanadium

Zinc



LABORATORY DETERMINED CONCENTRATIONS OF AS, CD, NI, AND CR
SBC CERCLA PHEA

FIGURE 2–6
ROCKER AREA

LABORATORY DETERMINED CONCENTRATIONS OF AS, CD, NI, AND CR
SBC CERCLA PHEA

FIGURE 2-7
ROCKER TOWNSITE

LABORATORY DETERMINED CONCENTRATIONS OF AS, CD, NI, AND CR
SBC CERCLA PHEA

FIGURE 2-8
RAMSAY AREA

LABORATORY DETERMINED CONCENTRATIONS OF AS, CD, NI, AND CR
SBC CERCLA PHEA

FIGURE 2-9
RAMSAY TOWNSITE

FIGURE 2–10 LABORATORY DETERMINED CONCENTRATIONS OF AS, CD, NI, AND CR: MILES CROSSING AREA, SBC CERCLA PHEA

TABLE 2-2

STATISTICAL SUMMARY OF SOIL PARAMETERS; SILVER BOW CREEK CERCLA

PUBLIC HEALTH ENVIRONMENTAL ASSESSMENT

	PARAMETER	MINIMUM	MAXIMUM	ARITHMETIC MEAN	GEOMETRIC MEAN	STANDARD DEVIATION	TOTAL NUMBER OF SAMPLES	NUMBER OF SAMPLES ABOVE DET.
1	Aluminum, total	8230.000	25200.000	14795.455	14179.554	4524.396	22	22
2	Antimony, total	<1.300	14.900	<5.148	<4.744	2.332	22	14
3	Arsenic, total	12.500	1180.000	123.750	57.349	248.402	22	22
4	Barium, total	62.400	465.000	249.564	233.652	84.594	22	22
5	Beryllium, total	0.440	1.400	0.852	0.791	0.315	22	22
6	Cadmium, total	0.840	23.300	5.093	3.776	4.848	22	22
7	Calcium, total	1380.000	59700.000	10729.545	7106.824	13056.740	22	22
8	Chromium, total	4.400	123.000	30.300	23.799	25.934	22	22
9	Cobalt, total	3.200	10.800	7.355	7.009	2.157	22	22
10	Copper, total	35.400	2780.000	409.805	217.836	669.842	22	22
11	Iron, total	13400.000	61400.000	21918.182	20263.599	10802.541	22	22
12	Lead, total	16.400	1510.000	317.436	190.257	338.072	22	22
13	Magnesium, total	1700.000	6980.000	3690.455	3526.905	1144.687	22	22
14	Manganese, total	210.000	1090.000	587.045	532.552	258.205	22	22
15	Mercury, total	<0.050	1.100	<0.316	<0.222	0.185	22	11
16	Nickel, total	<0.750	19.700	<8.907	<6.990	4.321	22	19
17	Potassium, total	1920.000	7530.000	3687.273	3543.671	1152.625	22	22
18	Selenium, total	<0.150	1.800	<0.502	<0.477	0.266	22	13
19	Silver, total	<0.465	8.400	<2.192	<1.827	1.473	22	15
20	Sodium, total	72.200	1480.000	376.691	304.187	294.806	22	22
21	Thallium, total	<0.170	0.620	<0.257	<0.386	0.030	22	5
22	Vanadium, total	26.100	108.000	52.900	49.890	19.693	22	22
23	Zinc, total	71.400	2840.000	546.782	382.225	599.022	22	22
24	Gravel (wt. %)	0.800	18.500	4.041	2.661	4.720	22	22
25	Sand (wt. %)	23.400	79.100	61.132	59.600	12.253	22	22
26	Silt and Clay (wt. %)	11.400	75.100	34.827	31.959	14.181	22	22

NOTES:

1) All quantities are in mg/kg unless otherwise noted.
2) Less-than sign, "<", indicates the value is based on detection limit value since parameter is below detection.
3) In statistical calculations, values below the detection limit are included as 1/2 the detection limit value.
4) Results obtained at site '08A' were not included in the statistics.

TABLE 2-3

SOIL METALS CONCENTRATIONS[1]
EXCEEDING 100% OF THE GEOMETRIC MEAN,
SILVER BOW CREEK, PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT
ROCKER AND RAMSAY AREAS

Metal	Sb	As	Cd	Ca	Cr	Cu	Fe	Hg	Ni	K	Pb	Mn	Se	Ag	Na	Va	Zn
Geometric Mean(2)	<4.7	57	3.8	7,107	23.8	218	20,264	<0.22	7.0	3,544	190	532	<0.48	1.83	304	49.9	382
Station																	
SBC-SO-04A								0.80			874	1,090					
SBC-SO-07A	12.9	1,190	8.9			2,060	61,500	0.87		7,540			1.8	7.2	1,490		
SBC-SO-08A	313	24,900	151					17.7			576		5.3				
SBC-SO-09A								1.1			435						
SBC-SO-10C		364	7.0			2,780		1.1			601		1.2	8.4	645		1,520
SBC-SO-10E				59,800	74.9						407				652	108	
SBC-SO-14B		155				468											
SBC-SO-14E	10.7																
SBC-SO-26A											614						
SBC-SO-28B			23.3	33,800	123	511		0.83	15.4		1,520		1.4	4.1			2,850
SBC-SO-31C									17.7								
SBC-SO-33A	14.9		9.9						15.5		406						
SBC-SO-35A				19,800					14.2								
SBC-SO-37C			9.7								401			4.0			818
SBC-SO-38A		124															
SBC-SO-39E		114															
SBC-SO-45C			6.5		47.8				19.7								

NOTES:
(1) All Concentrations in mg/kg.
(2) Geometric Means from Table 2-2.

however, were obtained from areas exhibiting obvious tailings or mineralized material; some of these samples (e.g., sites 007A and 010C) were obtained from areas within the residential area of Rocker.

3.0 GROUNDWATER INVESTIGATION

3.1 METHODS

A review of Phase I RI groundwater quality data (MultiTech, 1987) revealed that no laboratory analyses for manganese were performed on samples obtained from wells completed in Silver Bow Creek alluvium. Additional groundwater samples were therefore collected during this study from four alluvial monitoring wells located adjacent to Silver Bow Creek between Rocker and Miles Crossing (Figure 3-1).

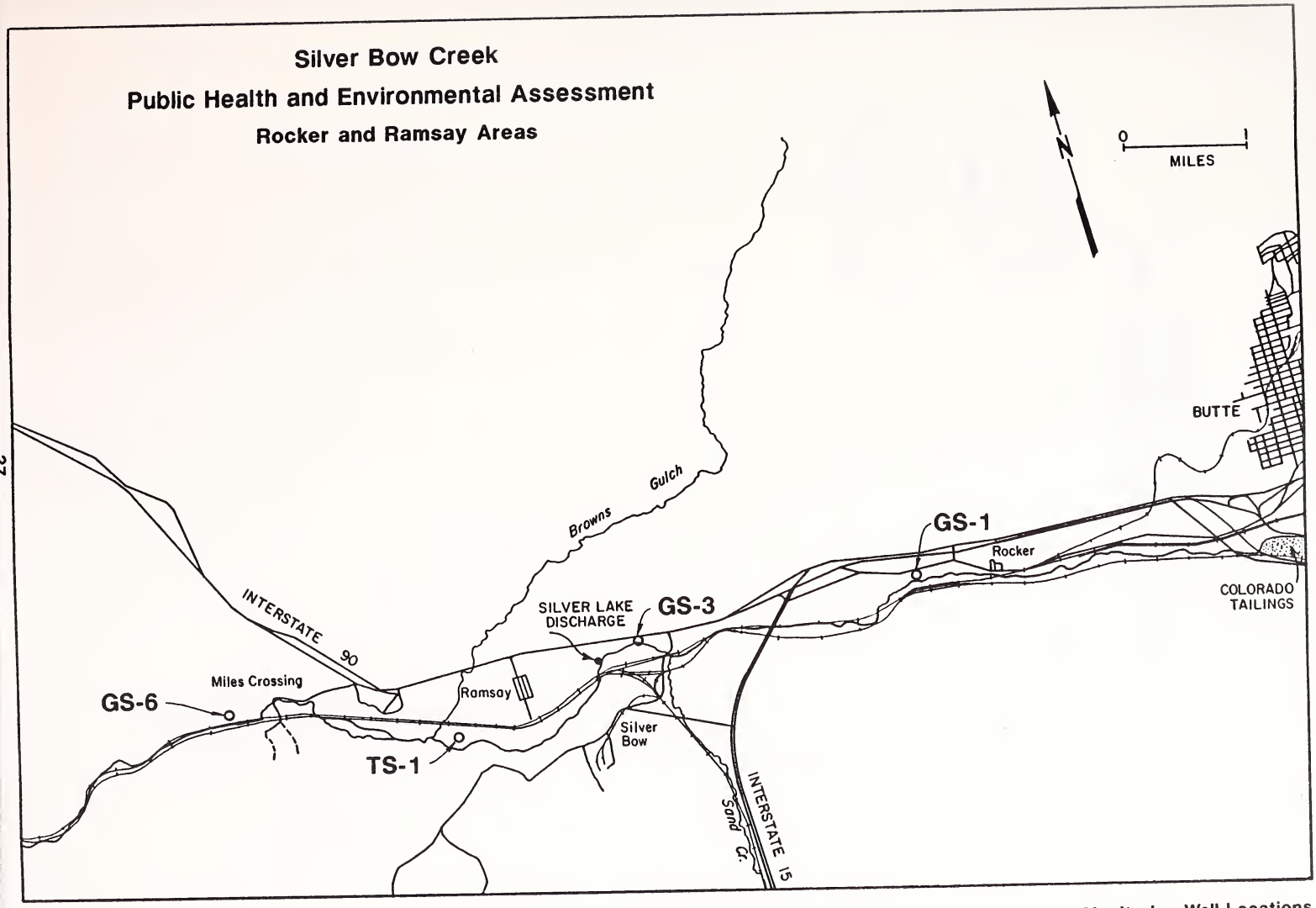
Monitoring wells sampled included GS-01, GS-03, TS-01, and GS-06 (Figure 3-1). Samples were shipped to an EPA contract laboratory for analysis of parameters listed in Table 3-1. Sample collection and QA/QC procedures used during this sampling effort are described in the project Sampling and Analysis Plan (CH2M HILL, 1988a).

3.2 CHANGES TO THE PROJECT WORK PLAN

No changes to the project sampling and analysis plan (CH2M Hill, 1988a) were implemented during completion of the groundwater sampling task.

3.3 PRESENTATION OF DATA

Analytical results of collected groundwater samples are contained in Appendix D. Table 3-2 summarizes groundwater quality data from the four monitoring wells sampled for both sampling episodes completed during the Phase I RI and for the sampling event completed during this study. Table 3-3 is a statistical summary of groundwater quality data resulting from this study.



Monitoring Well Locations
FIGURE 3-1

TABLE 3-1

GROUNDWATER PARAMETER LIST
SILVER BOW CREEK CERCLA
PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT
ROCKER AND RAMSAY AREAS

Field Parameters	Laboratory Parameters
Static Water Level	Aluminum
Temperature	Antimony
pH	Arsenic
Specific Conductivity	Barium
Dissolved Oxygen	Beryllium
Eh	Cadmium
	Calcium
	Chromium
	Cobalt
	Copper
	Iron
	Lead
	Magnesium
	Manganese
	Mercury
	Nickel
	Potassium
	Selenium
	Silver
	Thallium
	Vanadium
	Zinc

TABLE 3-2

SUMMARY OF GROUNDWATER DATA FROM MONITORING WELLS
TS-01, GS-01, GS-03, AND GS-06;
SILVER BOW CREEK CERCLA
PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

Well	Date	SWL	As	Cd	Cu	Fe	Pb	Zn	Mn
TS-01	06/85	9.7	<3.0	1.0	<14	93	<3.7	30	--
TS-01	07/85	10.0	3.6	3.4	<10	191	4.4	41	--
TS-01	12/85	10.1	3.1	2.4	<10	173	1.9	23	--
TS-01	08/88	10.5	<5	4.1	124	36.1	4.9	470	13,900
GS-01	01/85	3.3	<6.3	<.6	<40	<31	<1.1	<27	--
GS-01	02/85	3.5	<5	<1.1	<27	<28	<2.8	14	--
GS-01	06/85	3.5	3.8	<1.0	<14	20	<3.7	11	--
GS-01	08/88	3.0	<5	<1	<15.8	<23.2	11.8	34.1	671
GS-03	01/85	6.4	<7	<1	<40	<31	1.5	<27	--
GS-03	02/85	6.6	12	<1	<27	<28	<1.3	<10	--
GS-03	06/85	6.5	12	<1	<14	<16	<3.7	18	--
GS-03	08/88	7.7	8.4	1.6	21	<23.2	<3.4	95.3	47.6
GS-06	06/85	7.1	13	<1	<20	5800	2.3	672	--
GS-06	12/85	7.7	17	11	<24	24,900	<1.8	2,150	--
GS-06	08/88	8.8	15.1	4.1	<15.8	17,900	4.6	1730	5,370

Notes:

1. All concentrations in ug/L.
2. SWL = Static Water Level (ft) below measuring point.
3. < = less than
4. -- = Not determined

TABLE 3-3

STATISTICAL SUMMARY OF GROUNDWATER PARAMETERS; SILVER BOW CREEK CERCLA

PUBLIC HEALTH ENVIRONMENTAL ASSESSMENT

	PARAMETER	MINIMUM	MAXIMUM	ARITHMETIC MEAN	GEOMETRIC MEAN	STANDARD DEVIATION	TOTAL NUMBER OF SAMPLES	NUMBER OF SAMPLES ABOVE DET.
1	Aluminum, total	68.900	108.000	87.225	86.004	16.907	4	4
2	Antimony, total	<9.050	36.600	<15.938	<21.584	0.000	4	1
3	Arsenic, total	<2.500	15.100	<7.125	<7.504	2.369	4	2
4	Barium, total	124.000	260.000	176.000	168.613	61.455	4	4
5	Beryllium, total	(4)	(4)	(4)	(4)	0.000	4	0
6	Cadmium, total	<0.500	4.100	<2.575	<2.277	1.083	4	3
7	Calcium, total	40000.000	141000.000	71900.000	62464.283	47495.824	4	4
8	Chromium, total	<1.250	7.100	<3.650	<3.859	0.742	4	2
9	Cobalt, total	<3.400	14.600	<6.200	<8.231	0.000	4	1
10	Copper, total	<7.900	124.000	<40.200	<28.395	36.416	4	2
11	Iron, total	<11.600	17900.000	<4489.825	<136.563	6315.842	4	2
12	Lead, total	<1.700	11.800	<5.750	<5.484	3.055	4	3
13	Magnesium, total	6230.000	34800.000	17157.500	14005.679	12637.691	4	4
14	Manganese, total	47.600	13900.000	4997.150	1242.595	6393.053	4	4
15	Mercury, total	(4)	(4)	(4)	(4)	0.000	4	0
16	Nickel, total	<8.800	50.300	<27.075	<26.629	12.032	4	3
17	Potassium, total	4420.000	9180.000	6220.000	5979.021	2105.675	4	4
18	Selenium, total	<1.650	9.900	<3.713	<4.343	0.000	4	1
19	Silver, total	(4)	(4)	(4)	(4)	0.000	4	0
20	Sodium, total	18600.000	136000.000	61300.000	46668.610	52501.302	4	4
21	Thallium, total	(4)	(4)	(4)	(4)	0.000	4	0
22	Vanadium, total	<2.450	8.000	<3.838	<5.539	0.000	4	1
23	Zinc, total	34.100	1730.000	582.350	226.724	788.991	4	4
24	pH (pH units)	6.700	7.400	7.000	6.995	0.316	4	4
25	Eh (mV)	-30.000	210.000	133.750	0.000	110.255	4	4
26	Static Water Level (-FT)	3.050	10.530	7.083	6.269	3.774	3	3
27	Dissolved Oxygen (mg/L)	2.200	7.900	4.300	3.722	2.685	4	4
28	Specific Conductance (umhos/cm)	343.000	1387.000	708.000	614.048	466.578	4	4
29	Temperature (degrees C)	8.000	11.000	9.750	9.685	1.258	4	4

NOTES:

1) All quantities are in ug/L unless otherwise noted.
2) Less-than sign, "<", indicates the value is based on detection limit value since parameter is below detection.
3) In statistical calculations, values below the detection limit are included as 1/2 the detection limit value.
4) There were no values above the detection limit.

Metals concentrations in groundwater sampled from monitoring wells were generally similar to concentrations measured in samples obtained from the same wells in 1985 during the Phase I RI (MultiTech, 1987), with the exception of copper and zinc in monitoring well TS-01, and zinc in monitoring well GS-03. Copper and zinc concentrations in TS-01 during the present study study were 124 ug/L and 470 ug/L, respectively. These compare with copper and zinc concentrations measured in 1985 of <14 ug/L and 41 ug/L for copper and zinc, respectively. The zinc concentration in GS-03 was 95.3 ug/L during this study and 18 ug/L in 1985.

Static groundwater levels were measured in all four monitoring wells prior to purging and sampling. Water levels at the times of previous sampling events, as well as for this sampling event, are presented in Table 3-2. Changes in water levels do not appear to correlate with measured changes in groundwater metals concentrations.

4.0 ENVIRONMENTAL MEDIA LITERATURE REVIEW

4.1 METHODS

A literature review was performed to identify and summarize soil, surface water, and groundwater metals data that are possibly relevant to establishing pre-mining concentrations of metal parameters at the Silver Bow Creek CERCLA site. Pre-mining concentrations of metals in these media are necessary to calculate the increased health risk to humans attributable to mine waste material deposited along Silver Bow Creek. This information may also be useful in establishing cleanup criteria for the site.

Data were gathered from the following state and federal agencies: Montana Department of Health and Environmental Sciences, Water Quality Bureau; Montana State Library, Natural Resource Information System; Montana Bureau of Mines and Geology; United States Geological Survey; Los Alamos Scientific Laboratory; and Gordon Environmental Studies Laboratory, University of Montana. Additional data were collected from various published sources and reports prepared for the U.S. Environmental Protection Agency.

Metal concentrations in soil, surface water, and groundwater are dependent on numerous environmental and geologic factors and generally vary widely from location to location. Because of this, emphasis was placed on reviewing reports and data collected in the region surrounding the Butte area, particularly those related to the Boulder Batholith. Data were also collected from regional investigations to allow comparison of local data to ranges and averages of metal concentrations obtained from more diverse geologic areas.

Data collected during the literature review were, by necessity, obtained from a variety of sources. Due to the various objectives of the researchers performing the referenced studies, numerous methods were used

in sampling, laboratory analyses, and in reporting the data. Brief summaries of methods used in studies referenced in this report are provided in Appendix E.

Several of the studies evaluated during the literature review did not present statistical analyses of the data generated during their investigations. For these data, an arithmetic mean was calculated for a representative subset of the data selected from those data presented. The procedure used to select a representative data subset from each study is described in Appendix E.

Despite differences in sample collection and laboratory analytical methods, numerous studies reported metal concentrations in the same general range for the same media. A direct comparison of statistical data from study to study, however, is not a valid use of the collated data sets because of the aforementioned factors. Examination of reported ranges in element concentrations is probably a more prudent approach in comparing reported metals concentrations for various media to those at the Silver Bow Creek CERCLA site.

4.2 SOILS

All elements, including copper, lead, zinc, cadmium, and arsenic occur naturally in the environment as components of various mineralized rock and, via weathering and erosion, are present in soil and stream sediments. The Butte ore bodies represent a natural concentration of these elements that form mineable ore deposits.

Geochemical investigations in the minerals industry and academia have identified a direct correlation between some mineralized ore deposits and elevated metal concentrations in residual soils and stream sediments developed in these same areas. Metals concentrations in soils and stream sediments generally decrease with increasing distance from the source (Peters, 1978). An attempt was therefore made during this literature

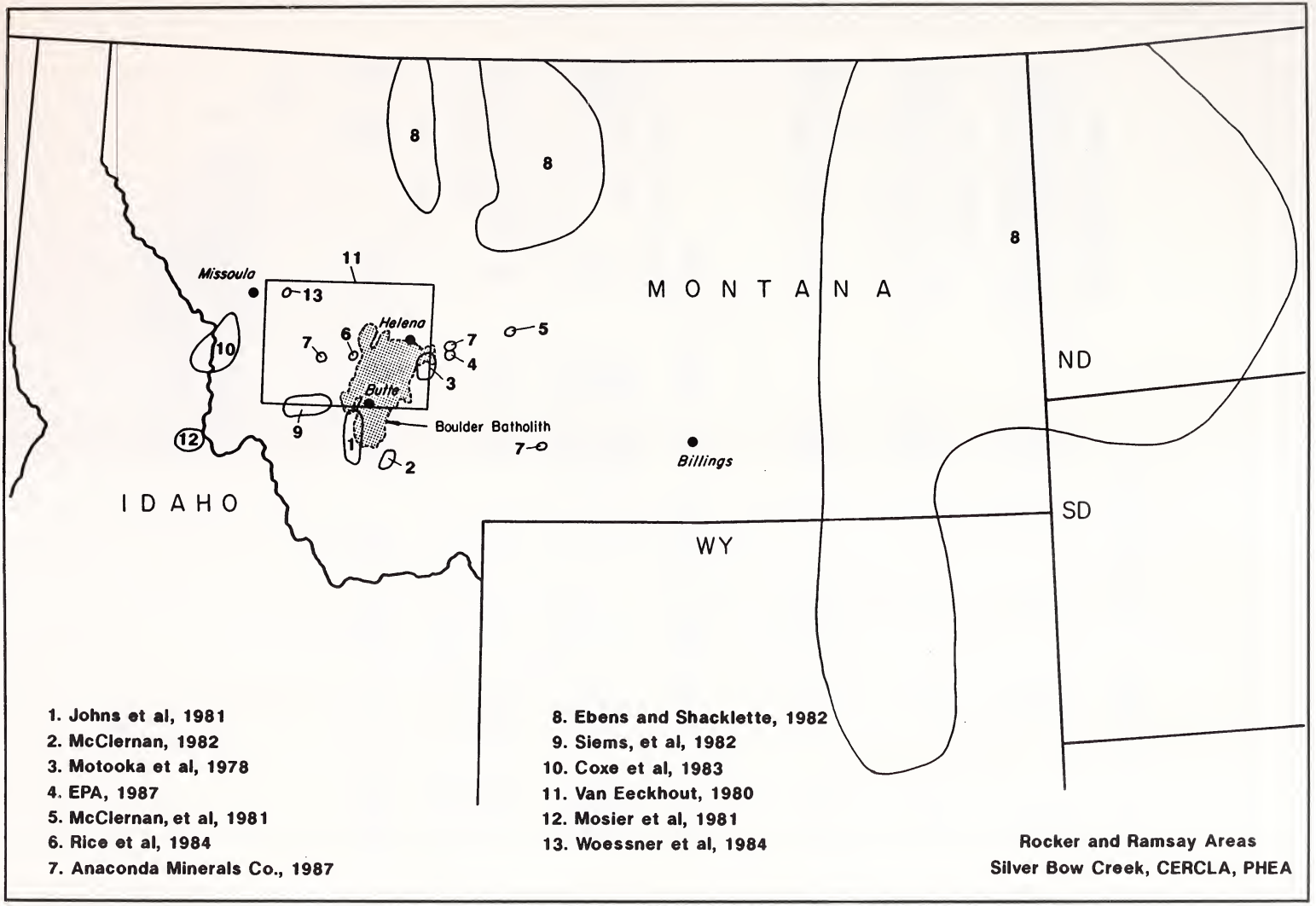
review to seek data which are representative of naturally occurring concentrations in areas which are geologically similar to the Silver Bow Creek CERCLA site.

Figure 4-1 shows locations of the various studies evaluated during this literature review with respect to metal concentrations in soils, bedrock, and stream sediments. Tables 4-1, 4-2, and 4-3 summarize analytical data contained in these studies for soil, rock, and stream sediment, respectively.

Data presented in Table 4-1, 4-2, and 4-3 are grouped into three separate categories to provide easy reference to and comparison between local and regional elemental abundances. The "Regional Compilations" category presents analytical data from studies which evaluated relatively large areas exhibiting a variety of geologic, climatologic and hydrologic environments. The "Local Mineralized" category presents analytical data from studies conducted in mineralized areas proximal to the Silver Bow Creek CERCLA site. The "Local Compilations" category presents analytical data from studies conducted near the Silver Bow Creek CERCLA site whose focus was to define pre-mining metal concentrations in an area or to determine metal concentrations in an area being evaluated for mineral resource potential.

Data from studies contained in "Regional Compilations" category (Tables 4-1, 4-2, 4-3) provide an indication of typical metal concentrations in various regions of the United States. Overall, average values for various elements presented are similar for studies evaluated.

Analytical data presented in the "Local Mineralized" category (Tables 4-1 and 4-2) are derived from studies completed within mining districts in Montana. In general, the reported average concentrations for metals at these sites are elevated related to the tabulated "Regional" and "Local Compilations" values. Differences in sample collection procedures may account for some of the variation, as soils for these studies were



Study Area Locations For Cited References of Rock, Soil and Stream Sediment Data, Montana.

FIGURE 4-1

TABLE 4-1

SOIL METALS ANALYSES, REGIONAL AND LOCAL COMPILATIONS, SILVER BOW CREEK CERCLA SITE
PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

		n	As Avg(1)	As Range	Ba Avg(1)	Ba Range	Be Avg(1)	Be Range	Cd Avg(1)	Cd Range	Cr Avg(1)	Cr Range
A. Regional Compilations												
Shacklette, H.E. et al., 1984	Western U.S.	778	5.5	<.1-97	580	70-5000	.68	<1-15	--	--	41	3-2000
Gough, L.P. et al., 1984	Alaska	35	--	--	722	89-3100	1.6	1-7	--	--	63.6	8-240
Kabata-Pendias & Pendias, 1984	U.S. Soils, overlying granite & gneiss	--	3.6	.07-15	785	300-1500	1.6	1-2	--	--	--	--
Ebens and Shacklette, 1982	Northern Plains Region	136	7.1	<.1-216	1,100	420-2320	1.6	<.22-3.5	--	--	45	11-160
B. Local Mineralized												
Motooka, J.M. et al., 1978	Elkhorn Wilderness, MT	20	--	--	885	700-1500	2	1-7	--	--	137	50-300
Johns, W.M. et al., 1981	Western Highland Mountains, MT	10,508	--	--	--	--	--	--	--	--	--	--
McClernan, H.G. et al., 1981	Newlan Creek, MT	194	--	--	--	--	--	--	--	--	--	--
C. Local Compilations												
EPA, 1987	E. Helena ASARCO Site, MT	3	16.5	15-18	130	110-142	1.01	.65-1.40	.24	.17-.30	15.3	14.0-17.0
Rice, P.M. et al., 1984	Kohrs Ranch (Blackfoot River), MT	1	4	--	--	--	--	--	<.1	--	--	--
Anaconda Minerals Co., 1987	Mill Creek R1, MT	19	9.3	2-146	--	--	--	--	.9	<.4-3.3	--	--

	n	Cu Avg(1)	Cu Range	Fe Avg(1)	Fe Range	Pb Avg(1)	Pb Range	Mn Avg(1)	Mn Range	Hg Avg(1)	Hg Range	Ni Avg(1)	Ni Range	Se Avg(1)	Se Range	Ag Avg(1)	Ag Range	Zn Avg(1)	Zn Range
A. Regional Compilations																			
Shacklette, 1984	21	2-300	21,000	1000-100,000	17	<10-700	380	30-5000	.046	<.01-4.6	15	<5-700	.23	<.1-4.3	--	--	55	10-2000
Gough, 1984	24.4	4-50	36,000	9,000-87,000	15.7	<4-43	600	200-2600	--	--	33	4-190	--	--	--	--	74.3	3-140
Kabata, et al.	24	7-70	--	--	21	10-50	540	150-1000	.08	.01-.14	--	--	.40	<.01-1.2	--	--	73.5	30-125
Ebens & Shacklette	19	4.3-110	21,000	2600-65,000	16	5.1-41	330	30-3800	.023	<.01-07	18	4.3-64	.45	<.1-20	.14	<.22-.49	63	14-170
B. Local Mineralized																		
Motooka, J.M., 1978	45	10-200	62,000	20,000-100,000	48.3	15-150	1070	500-2000	--	--	48.5	20-150	--	--	--	--	106.5	30-230
Johns, W.M., 1981	50	--	--	--	60	--	--	--	--	--	--	--	--	--	2.0	--	126	--
McClernan, H.G. et al., 1981	23	4-55	--	--	37	10-100	--	--	--	--	--	--	--	--	.7	0.4-1.6	77	20-180
C. Local Compilations																		
EPA, 1987	16.3	16.0-17.0	15,248	14,500-16,300	11.6	10.0-13.0	336	270-410	.08	.09-.12	13.3	13.0-14.0	.07	.07-.07	.20	.09-.45	46.9	39.9-53.9
Rice, 1984	13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
AMC, 1987	--	--	--	--	35.7	<1.6-404	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

1. All units in mg/kg
2. Dashes indicate not reported.
3. (1) Average determination methods contained in Appendix E.
4. Abbreviations:
   - n = number of samples
   - ND = Below Detectable Limits
   - < = less than

TABLE 4-2

BEDROCK METALS ANALYSES, REGIONAL AND LOCAL COMPILATIONS, SILVER BOW CREEK CERCLA SITE, PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

		n	As Avg(1)	As Range	Ba Avg(1)	Ba Range	Be Avg(1)	Be Range	Cd Avg(1)	Cd Range	Cr Avg(1)	Cr Range
A. Regional Compilations												
Mosier et al., 1981	Idaho Batholith	100	--	--	1261	<20->5000	2.24	<1-10	--	--	--	--
Adriano, 1986	Average Igneous Rocks	--	2.0	.2-13.8	700	300-1800	2.3	--	.15	.003-0.18	20	2-90
Hawkes, 1957	Igneous Rocks Element Abundance	--	5	--	250	--	6	--	.15	--	200	--
B. Local Mineralized												
McClernan, H.G., 1982	S. Highland Mts. - Precambrian gneisses, MT	66	--	--	--	--	--	--	.17	<.1-.5	31.5	<1-273
Motooka, et al., 1978	Elkhorn Volcanics, and Assoc. Plutonics, MT	80	--	ND-500	959	20-3000	1.44	ND-70	--	--	211.5	ND-1500

	Cu Avg(1)	Cu Range	Fe Avg(1)	Fe Range	Pb Avg(1)	Pb Range	Mn Avg(1)	Mn Range	Hg Avg(1)	Hg Range	Ni Avg(1)	Ni Range	Se Avg(1)	Se Range	Ag Avg(1)	Ag Range	Zn Avg(1)	Zn Range
A. Regional Compilations																		
Mosier et al., 1981	--	--	24,000	5000-100,000	22	10-50	308	100-1000	--	--	--	--	--	--	--	--	--	--
Adriano, 1986	15	4-30	--	14,000-30,000	18	6-30	--	--	.06	.005-.40	8	2-20	.05	--	--	--	40	5-140
Hawkes, 1957	70	--	50,000	--	16	--	1000	--	--	.077-0.5	80	--	.09	--	.1	--	132	--
B. Local Mineralized																		
McClernan, H.G., 1982	27.5	<1-141	--	-- - --	2.1	<1-19	--	--	--	--	18.5	2-65	--	--	.23	<.2-.8	28.5	<1-88
Motooka, J.M. et al., 1978	72.8	<5-1000	65,000	3000-150,000	33.6	ND-200	844	20-5000	--	--	36.8	ND-200	--	--	--	--	61.5	<10-200

Notes:

1. All units in mg/kg
2. Dashes indicate not reported.
3. (1) Average determination methods contained in Appendix E.
4. Abbreviations:
   - n = number of samples
   - ND = Below Detectable Limits
   - < = less than

TABLE 4-3

STREAM SEDIMENT METALS ANALYSES, REGIONAL AND LOCAL COMPILATIONS, SILVER BOW CREEK CERCLA SITE
PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

		n	As Avg(1)	As Range	Ba Avg(1)	Ba Range	Be Avg(1)	Be Range	Cd Avg(1)	Cd Range	Cr Avg(1)	Cr Range
A. Regional Compilations												
Ebens et al., 1982	Northern Plains Region	60	5.5	1.7-22	540	260-1000	2.0	.53-4.6	--	--	72	22-300
Coxe, B.W. et al., 1983	Selway-Bitterroot Wilderness, ID-MT	1142	--	--	556	100-2000	2.2	N-30	--	--	42.9	ND-2000
B. Local Compilations												
Siems, S.D. et al., 1982	Anaconda-Pintlar Wilderness, MT	25	--	--	520	200-700	3.26	1-10	--	--	34	<10-70
Van Eeckhout, 1980	Boulder Batholith, MT	1951	--	--	--	--	--	--	--	--	--	--
Motooka, J.M., 1978	Elkhorn Wilderness, MT	25	--	--	760	300-1500	1.7	<1-5.0	--	--	169	10-700
Woessner, W.W. et al., 1984	Milltown, MT	11	7.7	5.5-13	--	--	--	--	0.7	0.2-1.5	--	--

	Cu Avg(1)	Cu Range	Fe Avg(1)	Fe Range	Pb Avg(1)	Pb Range	Mn Avg(1)	Mn Range	Hg Avg(1)	Hg Range	Ni Avg(1)	Ni Range	Se Avg(1)	Se Range	Ag Avg(1)	Ag Range	Zn Avg(1)	Zn Range
A. Regional Compilations																		
Ebens et al., 1982	22	7.4-50	23,000	15,000-91,000	5.9	<1.2-20	440	170-2900	.055	.03-.12	24	10-45	.19	<.1-.46	--	--	71	42-120
Coxe, B.W., 1983	10.4	<5-500	30,000	7,000-100,000	21	10-70	590	100->5000	--	--	14.1	N-300	--	--	--	--	--	--
B. Local Compilations																		
Siems, S.D., 1982	29.9	5-200	19,800	5,000-50,000	17.2	10-30	584	200-1000	--	--	14.4	5-50	--	--	--	--	67.4	40-140
Van Eeckhout, 1980	44	5-1500	--	--	14	2-2500	620	20-10,000	--	--	--	--	--	--	--	--	65	5-2000
Motooka, J.M., 1978	45.4	15-70	78,000	50,000-200,000	56	20-150	1462	500-3000	--	--	27.9	<5-70	--	--	--	--	159.6	60-1000
Woessner, W.W., 1984	40.2	17-131	21,200	18,500-23,400	18	12-26	281	202-361	--	--	--	--	--	--	--	--	128	60-373

Notes:

1. All units in mg/kg
2. Dashes indicate not reported.
3. (1) Average determination methods contained in Appendix E.
4. Abbreviations:
   - n = number of samples
   - ND = Below Detectable Limits
   - < = less than

primarily collected from a deeper or basal soil horizon rather than from surficial soils. It is probable that some dilution in metal concentrations of the surface soils can be expected as metals are leached naturally into the subsoil.

"Local Compilations" metals data for soils (Table 4-1) include results from three studies in southwestern Montana which attempted to quantify background concentrations for areas exhibiting metals contamination. The reported concentrations represent values determined by the studies to be representative of expected preindustrial conditions in these areas.

Because of inherent differences in methodologies used to collect and analyze samples in each referenced study presented in Tables 4-1, 4-2, and 4-3, it is difficult to provide a statistically valid comparison of the data. The data represent ranges of concentrations for natural elements present in soils, rocks, and sediments in the areas in which the samples were collected. Elemental concentrations tabulated in Tables 4-1 though 4-3 are probably representative of natural concentrations of metals in the environment but may vary from pre-mining concentrations present in the Silver Bow Creek CERCLA area due to natural variations of element concentrations in bedrock as well as variations in climate and hydrologic conditions from site to site. However, the data may be useful for comparative purposes and may provide a basis for delineating areas within the Silver Bow Creek CERCLA site which have been contaminated by metals.

Ranges of element concentrations in soils reported in Table 4-1 are summarized in Table 4-4. For comparative purposes, ranges of laboratory determined element concentrations for selected samples obtained from the Rocker Area and the Ramsay/Miles Crossing areas during this study are included in Table 4-4. Rocker and Ramsay/Miles Crossing samples included in Table 4-4 represent those obtained from areas not immediately adjacent to obvious tailings-impacted areas. Review of Table 4-4 indicates that metals concentrations in soil samples collected in the Rocker and Ramsay/Miles Crossing areas are within the same order of magnitude as the other data sets.

TABLE 4-4

RANGES OF SOIL METALS CONCENTRATIONS (mg/kg)
SILVER BOW CREEK CERCLA, PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT
ROCKER AND RAMSAY AREAS

Parameter	Regional Compilations (1)	Local Mineralized (2)	Local Compilations (3)	Rocker Area (4)	Ramsay Area (5)
As	<0.1 - 216	-	2 - 146	12.5 - 24,900	17.0 - 124
Ba	70 - 5,000	700 - 1,500	110 - 142	62.5 - 298	154 - 466
Be	<0.2 - 15	1 - 7	0.65 - 1.4	0.45 - 1.2	0.44 - 1.4
Cd	-	-	0.17 - 3.3	0.84 - 151	2.3 - 23.3
Cr	3 - 2,000	50 - 300	14 - 17	4.4 - 74.9	18 - 123
Cu	2 - 300	4 - 200	16 - 17	40.4 - 2,780	82 - 511
Fe	1,000 - 100,000	20,000 - 100,000	14,500 - 16,300	15,400 - 61,500	13,400 - 33,000
Pb	<4 - 700	10 - 150	<1.6 - 404	16.4 - 874	84 - 1,520
Mn	30 - 5,000	500 - 2,000	270 - 410	290 - 1,090	210 - 710
Hg	0.01 - 4.6	-	0.09 - 0.12	<0.1 - 17.7	<0.1 - 0.83
Ni	4 - 700	20 - 150	13 - 14	<1.7 - 13	4.1 - 19.7
Se	<0.01 - 20	-	0.07 - 0.07	<0.3 - 5.3	<0.3 - 1.4
Ag	<0.22 - 0.49	0.4 - 1.6	0.09 - 0.45	<0.93 - 8.4	<0.93 - 4.1
Zn	3 - 2000	20 - 230	40 - 54	71.4 - 1,520	189 - 2,850

1. Range of Regional Compilations presented in Table 4-1.
2. Range of Local Mineralized investigations presented in Table 4-1.
3. Range of Local Compilations presented in Table 4-1.
4. Range of Laboratory Concentrations of Rocker Area Soil Samples; Includes Stations SBC-SO-01D, 04A, 07A, 08A, 09A, 10C, 10E, 14B, 15B, 17D, and 19A.
5. Range of Laboratory Concentrations of Ramsey and Miles Crossing Soil Samples; Includes Stations SBC-SO-26A, 28B, 31C, 33A, 35A, 37C, 38A, 39E, 43A, 45C, and 65C.

Average concentrations of metals in the Rocker and Ramsay/Miles Crossing area soils (Table 4-4) generally fall above the "Regional" and "Local" concentrations but below the "Local Mineralized" concentrations.

This may indicate some type of enrichment has occurred in the area, either naturally or by man-made means. By selecting samples for this analysis from areas not located immediately adjacent to obviously impacted areas, the fraction of metals content due to mine-related activity is probably minimized. Therefore, concentrations presented in Table 4-4 for the Rocker and Ramsay/Miles Crossing areas may be more representative of "natural" site concentrations for this portion of the Silver Bow Creek CERCLA area for the following reasons:

- The samples were collected from the same environment as the study area, thereby reducing error due to differing site physiography, geology, and hydrology.

- The sampled material is representative of the 0 to 1 inch soil horizon, the depth of interest in evaluating public health risks.

- Analytical techniques used were standardized to provide less bias in resultant data.

It is, however, impossible to accurately determine the contribution of metals to the soils due to mine-related activity or to airborne transmission in the Rocker and Ramsay/Miles Crossing areas.

4.3 SURFACE WATER DATA

Locations of sites from which surface water analytical data were obtained during this literature review are shown on Figure 4-2. These data are presented in Table 4-5 and summarized in Table 4-6.

Literature Review Surface Water Locations Boulder Batholith Area

FIGURE 4-2

TABLE 4-S

SURFACE WATER QUALITY DATA FROM LITERATURE REVIEW, VARIOUS LOCAL AND REGIONAL STUDIES
SILVER BOW CREEK, CERCLA SITE, PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

Location	Sampling Agency	Author	Source	Date Sampled	Flow(cfs)	n	Analysis Method	As	Ba	Be	Cd	Cr
Butte H_2O, Moulton Reservoir	MWQB	--	MWQB	1979-BB	NA	4	T	S	--	--	<1	--
Yankee Doodle Creek	AMC	Botz & Knudson, 1970	AMC	1969-70	NO	3	T	--	--	--	--	--
Upper Boulder River	MOFWP	Phillips & Hill, 19B6	MDFWP	19BS	30-200	10	TR	--	--	--	--	--
Upper Boulder River	MSU	Nelson, 1976	MSU	197S-76	2S-200	14	TR	--	--	<1	--	--
Upper Boulder River	MWQB	Pederson, 1977	MWQB	1977	NO	5	TR	--	--	--	<1	--
Upper Prickly Pear Creek	MWQB	Pederson, 1977	MWQB	1977	13	14	TR	2	--	--	<S	--
Upper Ten Mile Creek	MWQB	Pederson, 1977	MWQB	1977	3.4	1	TR	<1	--	--	<5	--
Little Blackfoot R. Ontario Ck	MWQB	Pederson, 1977	MWQB	1977	32	1	TR	B	--	--	<S	--
Little Blackfoot Lower	MWQB	Pederson, 1977	MWQB	1977	46	1	TR	7	--	--	<S	--
Blacktail Creek	MUJWRRC	Miller, 1974	MSL	196B-71	1.2-21	6-8	0	--	--	--	2	--
Browns Gulch	MUJWRRC	Miller, 1974	MSL	1969-71	.11-7	7-11	0	--	--	--	<10	--
SBC CERCLA RI, Blacktail Ck	MOHES	Multi Tech, 19B7	SBC R1	19B6-B7	26 (avg)	14	T	6	--	--	2	--
USGS, Bulletin 1000F	USGS	Hawkes, 19S7	MSL	-	Variable	Variable	--	1	160	--	--	S
USGS, Water Supply Paper 22S4	USGS	Hem, 19B5	-	-	Variable	Variable	--	<1	45	<1	1	1
							Range:	<1-B	45-160	--	<1-2	1-5

Location	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Zn
Butte H_2O, Moulton Reservoir	--	360	<S	--	--	--	--	--	--
Yankee Doodle Creek	20	200	--	--	--	--	--	--	30
Upper Boulder River	<10	--	--	--	--	--	--	--	10
Upper Boulder River	<10	490	<S0	--	--	--	--	--	20
Upper Boulder River	10	630	<S0	--	--	--	--	<10	20
Upper Prickly Pear Creek	<10	120	S0	<10	--	--	--	<10	<10
Upper Ten Mile Creek	<10	130	<S0	<10	<.2	--	--	<S0	<10
Little Blackfoot R. Ontario Ck	<10	90	<S0	<10	--	--	--	<10	10
Little Blackfoot Lower	<10	B0	<S0	<10	--	<20	--	<10	<10
Blacktail Creek	<10	B40	--	S0	--	--	--	--	30
Browns Gulch	<10	410	--	30	--	<20	--	--	30
SBC CERCLA R1, Blacktail Ck	40	B10	S	--	--	--	--	--	50
USGS, Bulletin 1000F	20	510	3	50	0.0S	15	B	0.01	10
USGS, Water Supply Paper 22S4	10	100-1000	1	-	0.2	10	0.2	0.3	20
Range:	10-40	120-B40	S-S0	<10-S0	.05-.2	15-20	0.2-B	.01-0.3	<10-S0

Notes:

1. All Concentrations are in ug/liter
2. Abbreviations:
   NO = Not Determined, NA = Not Applicable, n = number of samples
   TR = Total Recoverable, 0 = Dissolved, T = Total, avg = average, <=less than
3. Agency Codes: MWQB = Montana Water Quality Bureau
   MOFWP = Montana Department of Fish, Wildlife and Parks
   MSU = Montana State University
   MUJWRRC = Montana University Joint Water Resources Research Center
   USEPA = United States Environmental Protection Agency
   USFS = United States Forest Service
   MOHES = Montana Department of Health and Environmental Sciences
   AMC = Anaconda Minerals Company
   MSL = Montana State Library
   USGS = United States Geological Survey
   SBC-RI = Silver Bow Creek Remedial Investigation
4. Dashes indicate not reported

TABLE 4-5
(continued)

SURFACE WATER QUALITY DATA FROM LITERATURE, VARIOUS LOCAL AND REGIONAL STUDIES,
SILVER BOW CREEK CERCLA SITE, PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

Number	Location	Agency	Lat/Long	Source	Date Sampled	Flow (cfs) Range	Flow (cfs) Avg	n	Analysis Method	As	Ba	Be	Cd	Cr
1	Hail Columbia Gulch	USGS	46 04 28 112 35 25	Storett	75-80	.5-17	4.5	3-4	D	16	--	--	<10	--
2	Telegraph Gulch	USGS	46 06 32 112 37 34	Storett	76-79	2-.1	.7	2-3	D	15	--	--	<10	--
3	Browns Gulch	USFS	46 06 35 112 37 28	Storett	75-80	80-2	23	4-5	D	6	--	--	<10	--
4	Upper Lowland Cr.	USFS	46 07 27 112 27 34	Storett	76-80	9-0.6	3.8	1-9	D	7	--	--	<10	--
5	Little Boulder R.	MWQB	46 11 51 112 05 09	Storett	73-85	41-16	29	1-14	T	--	--	--	3	--
6	Little Boulder R.	USFS	46 12 21 112 06 32	Storett	76-81	150-1	59	1-19	D	<5	--	--	<10	<10
7	Muskrat Creek	MWQB	46 13 40 112 05 24	Storett	75	--	--	1-3	T	--	--	--	<100	--
8	Lowland Creek	USFS	46 14 45 112 24 57	Storett	75-81	3-245	57	1-3	D	7	--	--	<10	<10
9	Upper Boulder R.	USFS	46 15 09 112 30 12	Storett	76-81	2-135	50	1-8	D	--	--	--	<10	<10
10	Galena Gulch	MWQB	46 15 14 112 11 38	Storett	75-85	.5-1	.8	1-10	T	--	--	--	<1	--
11	Bison Cr. Lower,	USFS	46 15 20 112 20 28	Storett	75-85	10-214	102	1-3	T	--	--	--	<1	--
12	Rock Creek	USFS	46 15 33 112 30 15	Storett	78	.5-187	60	1-5	D	--	--	--	<10	<10
13	Thunderbolt Creek	USFS	46 15 41 112 28 34	Storett	75-78	.6-116	47	1-3	D	--	--	--	<10	<10
14	Boulder R. Basin	MWQB	46 15 54 112 18 56	Storett	75-86	35-117	75	14	D	--	--	--	<1	--
15	Prickly Pear Creek	USFS	46 21 58 112 00 16	Storett	79-80	4-36	16	2-6	T	7	--	--	--	--
17	Lump Gulch	MWQB	46 26 14 112 10 57	Storett	1973-76	--	--	9-10	T	11	--	--	<10	--
18	Park Lake	--	46 26 42 112 10 19	Storett	1980	NA	NA	2	T	10	--	<0.001	<	<
19	Fork Moose Creek	USFS	45 46 25 112 33 55	Storett	1976-79	6	2-5	2-5	D	13	--	--	<10	--
20	Upper Fish Creek	USFS	45 47 22 112 26 10	Storett	1980	17	1-9	1-9	D	--	--	--	<10	--
21	Basin Creek	USFS	45 50 23 112 31 32	Storett	1976	12	1		D	2	--	--	10	--
22	Fork Divide Creek	USFS	45 51 27 112 45 06	Storett	1976	15	1		D	3	--	--	10	--

Number	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Zn
1	<10	132	<50	22	--	13	--	<10	13
2	--	54	<50	43	.3	<10	--	<10	13
3	<10	134	<50	18	<.3	<10	--	<10	13
4	<10	415	46	27	<.3	<10	--	<10	18
5	15	1000	25	--	<1	--	--	<10	9
6	15	418	<50	29	--	<10	--	<10	70
7	<100	1600	20	--	--	--	--	<10	<10
8	<10	100	<50	<10	--	<10	--	<10	<10
9	<10	180	<50	16	--	<10	--	<10	<10
10	<10	1400	<50	--	--	--	--	<10	30
11	15	900	30	20	--	--	--	<10	30
12	<10	150	<50	200	--	<10	--	<10	<10
13	<20	90	<50	<10	--	<10	--	<10	<10
14	12	680	46	--	--	--	--	<10	18
15	<10	880	16	2	<.2	--	0.15	--	4
17	15	390	35	--	--	--	--	--	220
18	8	1440	5	260	0.2	9	--	--	65
19	--	400	50	36	0.3	<10	--	<10	<10
20	8	27	40	<10	--	--	--	<20	10
21	--	160	50	200	--	<10	--	<10	<10
22	10	50	50	10	--	10	--	10	10

Notes: (As on previous page)

TABLE 4-6

SUMMARY OF SURFACE WATER AND GROUNDWATER METALS
CONCENTRATIONS RANGES (UG/L)
SILVER BOW CREEK CERCLA
PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

	SURFACE WATER RANGE (1)	GROUNDWATER RANGE (2)
As	<1 - 15	<10 - <10
Ba	45 - 160	10 - 35
Be	<1 - <1	<4 - <4
Cd	<1 - 10	<2 - 10
Cr	1 - 10	<10 - 40
Cu	1 - 40	2 - 100
Fe	150 - 1440	<15 - 350
Pb	5 - 69	<1 - <1
Mn	<10 - 200	3 - 70
Hg	0.05 - 0.3	<0.2 - <0.2
Ni	9 - 46	<20 - <20
Se	0.2 - 8	<4 - <4
Ag	0.1 - 0.3	2 - 10
Zn	4 - 65	<10 - 180

Notes:

1. Summarized from Table 4-5.
2. Summarized from Table 4-7.
3. All concentrations
4. < = less than

The majority of surface water data included in Table 4-5 were collected from local streams draining areas underlain by the Boulder Batholith, although some data were collected from regional studies and other sources. Local stream drainages were included in the data summary only if no known mine tailings or acid mine drainage are present in the drainage. Compilations of regional studies by Hawkes (1957) and Hem (1985) may include data from mineralized areas or from contaminated streams. Chemistry data from streams draining the Boulder Batholith generally indicate that relatively low concentrations of metals are present in the area's surface water.

Historical accounts of the types of outcrops and mineralization present on the Butte Hill (Gidel, 1939; Smith, 1952; Weed, 1912) indicate that most surface exposures of veins and country rock were not highly mineralized with metals and that leaching of the exposed veins had resulted in a zone of supergene enrichment of metals 100 to 1,000 feet below the ground surface. Studies by Blanchard (1968) on leaching of outcrops in semiarid areas document the leaching of sulfide ore minerals from veins and rocks in the vadose zone. Supergene enrichment zones are found at numerous sulfide ore bodies (Park and MacDiarmid, 1975) and often contain the highest grade ore at a mine. Enrichment blankets are typically deposited at the water table elevation and can extend downward for hundreds of feet.

Surface waters draining the mineralized portions of the Summit Valley prior to disturbance by man were likely similar in quality to streams draining other portions of the Boulder Batholith (Table 4-5). This is because of the lack of mineralization at the surface in the Butte Hill area and the presence of an enrichment blanket at depth. It is possible that groundwater seepage into surface water drainages from the mineralized rock would have concentrations of metals higher than groundwater recharge from non-mineralized bedrock. However, the mineralized area represents only a small percentage of the total recharge area and, taken as a whole, did not likely significantly degrade the surface water quality.

4.4 GROUNDWATER DATA

Groundwater chemistry data were obtained during the literature review for wells completed in alluvium and bedrock within the Boulder Batholith area (Figure 4-3). Groundwater data are presented in Table 4-7; element concentration ranges are summarized in Table 4-6. Chemistry data for wells completed in bedrock units of the Boulder Batholith area were sparse; data were available, however, for most metals parameters.

Groundwater chemistry is affected by types of rock and alluvium through which the water flows and the residence time of the water in the ground. Typically, groundwater withdrawn from granitic rocks does not contain high levels of dissolved constituents due to the low solubility of most granitic minerals. However, if the host rock contains sulfide mineralization, the concentrations of dissolved metals and other elements would likely increase due to the leaching of percolating recharge water to the aquifer and the movement of groundwater through mineralized rock.

The lateral extent of migration of naturally-mineralized groundwater is controlled by water chemistry, pH, and redox changes as the water moves away from the mineralized area. It is likely that acidic conditions produced by sulfide oxidation would decrease as the water moves away from the sulfide source and mixing with other waters occurs. This would decrease the capability of the water to retain dissolved metals and cause metals precipitation. Groundwater quality at any one location surrounding a mineralized area is likely to be highly variable and would depend on numerous physical and chemical factors.

Literature Review Well Locations Boulder Batholith Area
FIGURE 4-3

TABLE 4-7

GROUNOWATER QUALITY DATA FROM LITERATURE REVIEW, SILVER 80W CERCLA SITE, MONTANA
PUBLIC HEALTH ANO ENVIRONMENTAL ASSESSMENT

No.	Oescription	Location	Agency	Source	Oate	TO (ft)	Aquifer	As	8a	Be	Cd	Cr
1	Trask	T05N R07W S11 CAB	Priv	NRIS	8/14/80	--	Alluvium	5.9	--	--	<2	<2
2	Ory Cottonwd Ck	T05N R08W S07 CBCO	MBMG	NRIS	8/9/80	--	Alluvium	--	--	--	<2	<2
3	Upper Basin Ck	T01N R07W S31 AB8C	USFS	NRIS	9/10/76	--	--	3	--	--	<10	--
4	Upper Moose Ck	T01N R07W S31 CC8A	USFS	NRIS	9/10/76	--	--	3.5	--	--	10	--
5	So. of 8utte	T02N R07W S07 008	MBMG	NRIS	1I/22/83	--	--	--	--	--	5	40
6	So. of 8utte	T02N R07W S08 CA8	Priv	NRIS	5/25/77	134	Alluvium	<2	--	--	<10	--
7	Mine flow	T02N R07W S16 AC00	MBMG	NRIS	4/7/86	71	Sediment	--	--	--	<2	<2
8	So. of Butte	T02N R07W S19 8AA	Priv	NRIS	5/25/77	--	--	<2	--	--	<10	--
9	So. of Butte	T02N R07W S23 0A8B	Priv	NRIS	--	140	Granite	.4	--	--	<2	<2
10	So. of Butte	T02N R08W S22 CBCA	Priv	NRIS	11/6/80	460	--	--	--	--	<10	<10
11	So. of Butte	T02N R09W S12 8CA8	MBMG	NRIS	--	--	Sediment	3.8	--	--	<2	<2
12	Oppor.Pond#16	T04N R10W S05 AC8	MOHES	TETRA TECH,1986	10/85	?	Alluvium	<3	13	<4	<2	7
13	Oppor.Pond#51	T05N R10W S32 C00	MOHES	TETRA TECH,1986	10/85	62	Alluvium	<3	32	<4	<2	<5
14	WSP-GW-09	T04N R10W S01 ACA	MOHES	CH2M HILL,1988b	1/88	35	Alluvium	<6.8	--	--	5	--
15	WSP-GW-01	T04N R10W S01 CB0	MOHES	CH2M HILL,1988b	I/88	79	Alluvium	<2.8	--	--	0.1	--
16	0W-103	T03N R07W S20 ABA	MOHES	MULTI TECH,1987	12/86	65	Alluvium	<3	--	--	1.2	--

No.	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Zn
1	10	--	--	--	--	--	--	<2	20
2	13	--	--	--	--	<10	--	3	<4
3	--	--	--	--	--	--	--	<10	10
4	--	--	--	--	--	--	--	<10	30
5	190	--	--	--	--	--	--	13	15
6	<10	--	--	--	--	--	--	--	180
7	<2	--	--	--	--	--	--	<2	36
8	<10	--	--	--	--	--	--	--	20
9	2	--	--	--	--	--	--	<2	11
10	110	--	--	--	--	--	--	<10	--
11	31	--	--	--	--	--	--	<2	64
12	<6	47	<15	14	<0.2	<20	<4	<3	46
13	<6	39	<3	6	<0.2	<20	<4	<3	14
14	<8	<15	<1	<3	--	--	--	--	<13
15	<8	<15	<1	<3	--	--	--	--	<13
16	<11	1000	<3	--	--	--	--	--	125

Notes:

1. All concentrations in ug/L.
2. Abbrevations: USGS = United States Geological Survey
   NRIS = Natural Resource Information System, Helena, Montana
   MBMG = Montana Bureau of Mines and Geology
   USFS = United States Forest Service
   Priv = Private
   MOHES = Montana Oepartment of Health and Environmental Sciences
3. < = less than
4. Oashes indicate not reported

5.0 DATA VALIDATION

5.1 INTRODUCTION

This section describes contract compliance, data validation and reduction, and presents quality assurance statements for data collection activities associated with work tasks completed in support of the site-wide PHEA at the Silver Bow Creek CERCLA site. Environmental samples collected during this investigation included surface soils and groundwater. Field procedures used during the various investigations and guidance for maintaining quality assurance and quality control during the course of the investigation are described in the project Sampling and Analysis Plan (SAP) (CH2M HILL, 1988a).

Collected samples were analyzed by certified contract laboratory program (CLP) laboratories using routine analytical services (RAS). Laboratory methods utilized, which included internal laboratory quality control procedures, were stipulated in the Contract Laboratory Statement of Work for Inorganics Analysis, No. 787 (EPA, no date).

5.2 CONTRACT COMPLIANCE SCREENING

Contract compliance screening represents the first level of data validation and reduction. This screening was stipulated by MDHES and EPA and its purpose was twofold:

- Evaluate whether contract performance requirements were met by the CLP laboratory in analyzing the submitted samples.

- Determine if specific natural samples were associated with certain out-of-control analytical situations and identify these specific samples.

Data reviewers were charged with evaluating each data package received from the laboratory. Specific guidelines and contract screening forms have been established by EPA Region VIII. The guidelines are found in the document Laboratory Data Validation: Functional Guidelines for Evaluating Inorganics Analysis (EPA, no date). Contract compliance screening forms (see Appendix E) were provided by Deanna Peterson, ESD/Deputy Project Officer, EPA Region VIII.

Each data package was reviewed using the guidelines and screening forms. The major evaluation parameters for data review and contract compliance were the following:

- Sample holding times
- Instrument calibration
- Calibration and preparation of blanks
- ICP interference
- Laboratory control samples
- Specific sample results including:
  - Laboratory duplicate sample analysis
  - Spiked sample results and graphite furnace atomic absorption QC analyses
  - Field and other QC sample results

Results of this contract compliance screening, with a narrative of findings, were then sent to the CLP/Deputy Project Officer for EPA Region VIII (John Tilstra). Resolution of conflicts regarding contract compliance

will be between EPA and the contract laboratory. In general, these data were judged acceptable for use. Contract compliance problems are contained in the QA/QC Reports presented in Appendix F.

5.3 DATA VALIDATION, REDUCTION, AND QUALITY ASSURANCE STATEMENTS

Data validation and reduction consisted of the development of several Quality Assurance Statements quantifying the accuracy, precision, representativeness, comparability, and completeness of data. The protocols for these procedures were outlined in the project SAP (CH2M HILL, 1988a).

5.3.1 Accuracy

Accuracy is measured as the ability of the analytical procedure to determine the actual quantity of a particular analyte in a sample. In these studies, accuracy was evaluated by determining the average recovery of the analytes in two different types of QC samples: blind field standards inserted into the sample train in the field, and laboratory natural matrix spikes. EPA-certified blind field standards were used during surface water and groundwater sampling episodes. These standards contained known concentrations of parameters measured. The concentrations of elements in the blind field standards were closely matched to the assumed levels at the Rocker and Ramsay areas.

The blind field standard used for soil was National Bureau of Standards (NBS) river sediment. This sample was inserted, at the prescribed frequency, into the sample train in the field. An accuracy statement was developed for each element of interest in each sample matrix using the statistical methodology described in the project SAP.

5.3.2 Precision

Precision of an analytical test result is reflected in the amount of scatter or variance that occurs in repeated measurements of a particular analyte. In these studies, two different types of QC samples were used to evaluate precision. Blind field replicates were included with the samples collected in the field at a frequency stipulated in the project SAP. Precision measurements based on these data reflect both field and laboratory variance. Laboratory duplicates were prepared in the laboratory and reflect only laboratory-generated variance. Data for these QC samples were extracted from the data base, and precision statements were calculated for each analyte of interest in each sample matrix using statistical procedures outlined in the project SAP.

5.3.3 Representativeness

For data validation and reduction efforts, representativeness deals with the evaluation of bias due to contamination, both external and cross-contamination. Analytical results for all types of field blanks and laboratory calibration and preparation blanks were evaluated in terms of the instrument and/or procedural detection limits to assess any contamination (bias) and identify its potential source. If contamination was found for a particular analyte in a specific matrix, then the data for associated natural samples may be adjusted at the discretion of the project manager, EPA, and the data users.

The results from blank analyses indicated measurable contamination for aluminum, barium, chromium, manganese, and nickel for groundwater and associated quality assurance samples. In addition, measurable contamination was found for aluminum, barium, cadmium, chromium, and lead in field blanks associated with soil samples. Data associated with the contaminated blanks were evaluated to determine if the contamination was present in most samples or if the contamination was an isolated occurrence that did not affect other samples.

The blank contaminant data were screened for those having levels greater than 2 x (times) their respective instrument detection limits (IDLs). Data for the natural samples associated with each blank were then compared to the 5 x criterion for any affected analyte. Any water sample reporting a concentration less than 5 x the maximum blank value was considered suspect and flagged "J" (estimated) if the blank concentration was 2x the IDL. The 5 x criterion was applied only when the level of the contaminant in the field blank was greater than 2 x the IDL to minimize misinterpretation of blank levels near the IDLs. Sample values reported below the IDL were not flagged as estimates. This evaluation of blank data follows EPA protocol as outlined in Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses (EPA, no date). Of the blanks associated with natural groundwater samples collected August 19, 1988 (MHM-730, 731), only aluminum and barium exceeded the 2 x IDL criteria. The data for these parameters have been appropriately flagged.

In the blanks associated with soil samples collected August 3-5, 1988, aluminum, barium, cadmium, chromium, and lead exceeded the 2 x IDL criteria. The blank values (water and bottle) were compared to soil concentrations assuming the 32 oz. glass soil sample jars contained about 945 grams of sample (approximately full). The calculation used was:

$$\frac{\text{(Total amount of contamination per bottle (ug/L)/945 gms soil)}}{\text{(1 gm sample/.21 digestant volume)}}$$

All contamination levels were found to be below the IDL levels for all parameters in soil digestants. The only contamination-affected soil sample was MHM-708 for chromium in which the concentration was less than 5 x the level found in the prep blank and was greater than 2 x the IDL. This value was flagged "J".

5.3.4 Completeness

Completeness was calculated following contract compliance and data validation and reduction. It was calculated as a percentage in two ways:

- Completeness = (# of valid samples/# of collected samples) x 100
- Completeness = (# of valid samples/# of planned samples) x 100

5.3.5 Comparability

Comparability was assessed prior to any sample collection and was addressed in the project SAP (CH2M HILL, 1988a).

5.4 SUMMARY QUALITY ASSURANCE STATEMENTS

Summary Quality Assurance (QA) Statements for soil and groundwater are presented in Tables 5-1 and 5-2, respectively. These are summary tables, and the information is based on individual QA statements for each analyte of interest in each sample matrix. The individual statements of accuracy, precision, representativeness, completeness, and comparability are found in Appendix F.

Summary quality assurance statements contain a reference as to the significance or insignificance of laboratory and field contamination on sample representativeness for each parameter. Contamination was labelled "significant" if field blanks for each data set contained concentrations above the method detection limit. Natural samples were flagged with appropriate modifiers if the concentration of the natural sample was less than 5 times the highest blank value for a given data set containing blank samples which were at least 2 times the method detection limits for a given parameter.

Table 5-1. Quality Assurance Statements for soil samples collected August 3-5, 1988. Rocker/Ramsay (Rocker-Miles Crossing). Silver Bow Creek. Case No. 10181.

Analyte	Analysis Type	ACCURACY % of Data	ACCURACY (90% C.L.) Value	ACCURACY Based on	PRECISION % of Data	PRECISION (90% C.L.) Value	PRECISION Based on	REPRENTATIVENESS (Contamination) Field	REPRENTATIVENESS (Contamination) Lab	COMPLETENESS Valid Samples as % of Planned	COMPLETENESS Valid Samples as % of Collected
Arsenic	FAA	100%	81.2± 46.0%	BFS	100%	± 31.7%	BFR	NS	NS	100%	100%
		100%	95.0±117.0%	LSR	100%	± 38.9%	LD				
Cadmium	ICP	100%	97.1± 45.5%	BFS	100%	± 18.0%	BFR	NS[1]	NS	100%	100%
		100%	93.2± 1.6%	LSR	100%	± 36.3%	LD				
Chromium	ICP	100%	62.5± 4.1%	BFS	100%	± 10.6%	BFR	NS[1]	S	100%	100%
		100%	99.1± 14.2%	LSR	100%	± 38.0%	LD				
Copper	ICP	100%	98.8± 1.5%	BFS	100%	± 3.8%	BFR	NS	NS	100%	100%
		100%	102.4± 82.1%	LSR	100%	± 40.4%	LD				
Lead	ICP	100%	92.2± 1.8%	BFS	100%	± 20.9%	BFR	NS[1]	NS	100%	100%
		100%	91.9± 75.8%	LSR	100%	±544.0%	LD				
Manganese	ICP	100%	86.9± 3.5%	BFS	100%	± 8.0%	BFR	NS	NS[2]	100%	100%
		100%	9.9±948.0%	LSR	100%	± 95.4%	LD				
Mercury	CV	100%	107.6± 21.9%	BFS	50%	±132.6%	BFR	NS	NS	100%	100%
		100%	115.7± 31.6%	LSR	--	NC	LD				
Nickel	ICP	100%	82.9± 45.0%	BFS	100%	± 99.6%	BFR	NS	NS	100%	100%
		100%	103.0± 9.5%	LSR	--	RPD=42.7%	LD				
Zinc	ICP	100%	97.4± 9.3%	BFS	100%	± 8.1%	BFR	NS	NS	100%	100%
		100%	88.4± 3.5%	LSR	100%	± 42.8%	LD				

Notes:

FAA - Furnace AA
ICP - Plasma Emission
CV - EPA Cold Vapor Method

LSR - Lab Spike Recovery
BFS - Blind Field Standard
BFR - Blind Field Replicate
LD - Laboratory Duplicate

NS - Not Significant
S - Significant
RPD - Relative Percent Difference when N = 1
NC - Not calculated due to values below the IDL

[1] Although levels were significant in water/bottle blanks, they were not significant when related to soil sample.
[2] Significant level in prep blank, but all samples > 5 x their contamination level.

Table 5-2. Quality Assurance Statements for water samples collected August 3-19, 1988. Rocker/Ramsay (Rocker-Miles Crossing). Silver Bow Creek. Case No. 10204.

Analyte	Analysis Type	ACCURACY % of Data	ACCURACY (90% C.L.) Value	ACCURACY Based on	PRECISION % of Data	PRECISION (90% C.L.) Value	PRECISION Based on	REPRENTATIVENESS (Contamination) Field	REPRENTATIVENESS (Contamination) Lab	COMPLETENESS Valid Samples as % of Planned	COMPLETENESS Valid Samples as % of Collected
Arsenic	FAA	100%	164.0±44.0%	BFS	100%	±123.0%	BFR	NS[2]	NS[2]	100%	100%
		--	74.5%R	LSR	--	NC	LD	NS[2]	NS[2]		
Cadmium	ICP	100%	63.5± 0.3%	BFS	100%	±178.0%	BFR	S[2]	NS[2]	100%	100%
		--	196.2%R[1]	LSR	--	NC	LD	NS[2]	NS[2]		
Chromium	ICP	100%	77.6± 3.8%	BFS	--	NC	BFR	S[2]	S[2]	100%	100%
		--	98.2%R	LSR	--	RPD=18.0%	LD	S[2]	S[2]		
Copper	ICP	100%	119.4± 0.0%	BFS	--	RPD=10.4%	BFR	NS[2]	NS[2]	100%	100%
		--	99.2%R	LSR	--	NC	LD	NS[2]	NS[2]		
Lead	FAA	100%	82.4±39.2%	BFS	--	RPD= 6.7%	BFR	S[2]	NS[2]	100%	100%
		--	33.0%R	LSR	100%	±369.0%	LD	NS[2]	NS[2]		
Manganese	ICP	100%	97.0± 0.0%	BFS	100%	± 22.4%	BFR	S[2]	NS[2]	100%	100%
		--	100.7%R	LSR	--	RPD= 0.045%	LD	S[2]	NS[2]		
Mercury	CV	100%	165.3±27.5%	BFS	--	NC	BFR	NS[2]	NS[2]	100%	100%
		--	68.0%R	LSR	--	NC	LD	NS[2]	NS[2]		
Nickel	ICP	100%	106.4±13.3%	BFS	100%	± 82.5%	BFR	S[2]	NS[2]	100%	100%
		--	101.5%R	LSR	--	NC	LD	S[2]	NS[2]		
Zinc	ICP	100%	77.6± 9.5%	BFS	100%	± 50.7%	BFR	NS[2]	NS[2]	100%	100%
		--	101.3%R	LSR	--	RPD=63.1%	LD	NS[2]	NS[2]		

Notes:

FAA - Furnace AA
ICP - Plasma Emission
CV - EPA Cold Vapor Method

LSR - Lab Spike Recovery
BFS - Blind Field Standard
BFR - Blind Field Replicate
LD - Laboratory Duplicate
RPD - Relative Percent Difference when N = 1
%R - Percent spike recovery when N = 1
NC - Not calculated due to values below the IDL

NS - Not Significant
S - Significant

[1] - Possible spiking error. Sample was a water blank. Post-digestion spike recovery =104.6%.

[2] - Contamination associated with natural and replicate samples collected on August 19, 1988 only.

5.5 QUALITY CONTROL OF FIELD MEASUREMENTS

Details of field procedures, observations, and measurements were described in the project SAP. Standard operating procedures for all field activities were appended to the SAP and contain all QC requirements for field measurements.

Field measurements obtained while groundwater samples were collected included water temperature, pH, specific conductance, Eh, and dissolved oxygen. Assessment of the precision of these field measurements was based on the field replicate determinations. The accuracy of these field measurements was based on standard operating procedures, instrument calibration in the field, and the professional judgment of the field sampling teams.

6.0 BIBLIOGRAPHY

Anaconda Minerals Company, 1987. Final Remedial Investigation Report, Mill Creek, Montana. Anaconda Smelter Superfund Site, First Operable Unit

Adriano, 1986. Trace Elements in the Terrestrial Environment: Springer-Verlag, New York.

Blanchard, R., 1968. Interpretation of Leached Outcrops: Nevada Bureau of Mines. Bulletin 66.

Botz, M.K. and Knudson, G.L., 1970. Hydrology of the Berkeley Pit Area: Private report to The Anaconda Company, Butte, Montana, April 7, 1970.

CH2M HILL, 1987. Technical Memorandum II, Evaluation of Data Needs, Site-Wide Public Health and Environmental Assessment, Silver Bow Creek CERCLA Site, December, 1987.

CH2M HILL, 1988a. Sampling and Analysis Plan, Silver Bow Creek CERCLA Site, Montana, Public Health and Environmental Assessment Data Collection, EPA Region VIII.

CH2M HILL, 1988b. Warm Springs Ponds Draft Feasibility Study. Agency Review Draft. August 30, 1988. Submitted to Montana Department of Health and Environmental Sciences, Helena, Montana.

Coxe, B.W. and Toth, M.I., 1983. Statistical Tables, Sample Locality Maps, and an Explanation of Data Sets for Samples from the Selway-Bitteroot Wilderness, Idaho County, Idaho, and Missoula and Ravalli Counties, Montana: USGS Open-File Report 83-54.

Ebens and Shacklette, H.T., 1982. Geochemical Concentrations in Soils and Other Surficial Materials of the Western Energy Region, Conterminous United States: USGS P.P. 1237.

EPA, 1987. Remedial Investigation of Soils, Vegetation and Livestock, E. Helena Site (ASARCO), E. Helena, Montana: EPA Work Assignment 68-8L30.0.

EPA, No date. Contract Laboratory Program Statement of Work for Inorganics Analysis, No. 787.

EPA, No date. Laboratory Data Validation: Functional Guidelines for Evaluating Inorganics Analysis, Office of Emergency and Remedial Response.

Gidel, M. H., 1939. History of Geology and Ore Deposits, in: Seven Talks about Mines, Butte Chamber of Commerce.

Gough, L.P., Peard, J.L., Severson, R.C., Shacklette, H.T., Tompkins, M.L., Stewart, K.C., and Briggs, P.H., 1984. Chemical Analyses of Soils and Other Surficial Materials, Alaska: USGS Open-File Report 84-423.

Hawkes, 1957. Principles of Geochemical Prospecting: United States Geological Survey Bulletin 1000-F.

Hem, J.D., 1985. Study and Interpretation of the Chemical Characteristics of Natural Water: United States Geological Survey Water-Supply Paper 2254.

Johns, W.M., and Lawson, D.C., 1981. Geochemical Soil Sampling in Southern Silver Bow and Northern Madison Counties, Montana; with Section on Geochemical Threshold and Anomalous Values by R.J. Peterson, 1981: MBMG Open-File Report 3-B.

Kabata-Pendias and Pendias, 1984. Trace Elements in Soils and Plants: CRC Press, Inc., Boca Baton, Florida.

Lepeltier, C., 1969. A Simplified Statistical Treatment of Geochemical Data by Graphic Representation: Economic Geology, volume 64, p. 538-550.

McClernan, H.G., 1982. Lithogeochemical Data from the Rochester Mining District, Madison County, Montana: MBMG Open-File Report 92.

McClernan, H.G. and Lawson, D.C., 1981. Geochemical Exploration of the Newland Creek Area, Meagher County, Montana: MBMG GM-24 (with text).

Miller, M.R., 1974. Hydrochemical Investigation of Selected Watersheds in Southwestern Montana: Montana University Joint Water Resources Research Center, Bozeman, Montana, 59715, Report No. 60, December, 1974.

Mosier, E.L., Pawlowski, M.R., Mutschler, F.E., Rehn, W.M., Lund, K.I., Coxe, B.W., and Yeoman, R.O., 1981. Analyses of Rocks and Stream Sediment from the Magruder Corridor Roadless Area, Idaho County, Idaho: USGS Open-File Report 81-891.

Motooka, J.M., McHugh, J.B., Miller, W.R., Ludington, S.D. and Greenwood, W.R., 1978. Analyses of Rock, Soils, Stream Sediments, and Heavy-Mineral Concentrates of the Elkhorn Wilderness, Montana: USGS Open-File Report 78-250.

MultiTech, 1987. Silver Bow Creek Remedial Investigation, Surface Water and Point Source Investigation, Appendix A, Parts 1 and 2, revised report and Appendix B, Groundwater and Tailings investigation. Montana Department of Health and Environmental Sciences, Helena, Montana.

Nelson, F.A., 1976. The Effects of Metals on Trout Populations in the Upper Boulder River, Montana: Montana State University MS Thesis, December, 1976.

Park, C. F., and MacDiarmid, R. A., 1975. Ore Deposits: W. H. Freeman and Company

Parslow, G. R., 1974. Determination of Background and Threshold in Exploration Geochemistry: Journal of Geochemical Exploration, volume 3, p. 319-336.

Pederson, D., 1977. An Assessment of Mining Impacts on Water Quality in the Northern Boulder Batholith: Statewide Section 208, Water Quality Management Planning, Land Use/Water Quality Relationships, October, 28, 1977.

Peters, W. C., 1978. Exploration and Mining Geology: John Wiley and Sons, New York.

Phillips, G. and Hill, K., 1986. Evaluation of Sources and Toxicity of Copper and Zinc in the Boulder River Drainage, Jefferson County - 1985: Pollution Control Office, Montana Department of Fish, Wildlife and Parks, Helena, Montana, April, 1986.

Rice, P.M. and Ray, G.J., 1984. Floral and Faunal Survey and Toxic Metal Contamination Study of the Grant-Kohrs Ranch National Historic Site: Gordon Environmental Studies Laboratory, Univ. of Montana.

Shacklette, H.T. and Boerngen, 1984. Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States: USGS P.P. 1270.

Siems, D.F., Welsch, E.P. and Zimbelman, D.R., 1982, Chemical Analyses of Minus-200 Mesh Stream Sediments of the Anaconda-Pintlar Wilderness, Beaverhead, Deerlodge, Granite, and Ravalli Counties, Montana: USGS Open-File Report 82-490.

Smith, R. J., 1952. History of the Early Reduction Plants of Butte, Montana: Reprint from De Re Metallica, Volume 18, Nos. 2 and 3.

Sonderegger, J.L. and Lawson, D.C., 1983. Hydrochemical Baseline Studies, Stillwater and Boulder Drainages, Sweet Grass and Stillwater Counties, Montana: MBMG Open-File Report 112.

Tennant, C. B., and White, M. L., 1959. Study of the Distribution of Some Geochemical Data: Economic Geology, volume 54, p. 1281-1290.

Tetra Tech, Inc., 1985. Soils Data Report, Anaconda Smelter RI/FS: Anaconda Mines Co., Document Control No. BAL TTB-055D0.

Tetra Tech, Inc., 1986. Geochemistry Report, Anaconda Smelter RI/FS: Anaconda Minerals Company, July, 1986.

Van Eckhout, E. M., 1980. Utilizing the Geochemical Data from the National Uranium Resourse Evaluation (NURE) Program: An Evaluation of the Butte Quadrangle, Montana: Prepared for University of California Los Alamos Scientific Laboratory under Contract No. NP8-6263F-1, December, 1980.

Weed, W. H., 1912. Geology and Ore Deposits of the Butte District, Montana: U. S. Geological Survey Professional Paper 74, 262 p.

Woessner, W.W. and Moore, J.N., 1984. Arsenic Source and Water Supply Remedial Action Study, Milltown, Montana: Department of Geology, University of Montana.

APPENDIX A

X-RAY FLUORESCENCE INDEX VALUES

SELECTED X-RAY FLUORESCENCE DATA FOR SILVER BOW CREEK SAMPLES

FILE	SITE	DATE	Index Values: Arsenic	Chromium	Copper	Iron	Krypton	Lead	Manganese	Mercury	Nickel	Selenium	Zinc	Barium (Fe source)	Cadmium (Fe source)	Silver (Fe source)
RSS001A		08-02-88	0.75	0.51	0.47	1.17	0.64	0.63	1.09	0.52	0.41	0.48	0.48	0.13	0.40	0.33
RSS0018		08-02-88	0.43	0.46	0.31	1.36	0.36	0.35	1.20	0.30	0.35	0.28	0.26	0.18	0.36	0.30
RSS001C		08-02-88	0.38	0.67	0.31	2.24	0.37	0.33	1.95	0.29	0.41	0.26	0.25	0.23	0.46	0.37
RSS001D		08-02-88	0.37	0.47	0.27	1.36	0.35	0.32	1.23	0.27	0.31	0.25	0.23	0.20	0.49	0.39
RSS001E		08-02-88	0.45	0.56	0.32	1.72	0.37	0.37	1.52	0.32	0.39	0.29	0.27	0.19	0.42	0.35
RSS003A		08-02-88	0.41	0.53	0.35	1.63	0.37	0.34	1.42	0.29	0.39	0.28	0.29	0.18	0.40	0.34
RSS0038		08-02-88	0.40	0.55	0.32	1.70	0.35	0.33	1.53	0.28	0.38	0.26	0.27	0.19	0.36	0.29
RSS004A		08-02-88	0.43	0.49	0.34	1.45	0.38	0.36	1.28	0.31	0.37	0.29	0.31	0.18	0.43	0.34
RSS0048		08-02-88	0.35	0.40	0.25	1.26	0.31	0.29	1.09	0.26	0.29	0.23	0.22	0.16	0.34	0.27
RSS004C		08-02-88	0.46	0.53	0.37	1.63	0.38	0.38	1.40	0.31	0.40	0.31	0.32	0.18	0.44	0.35
RSS005A		08-02-88	0.47	0.42	0.39	1.38	0.40	0.38	1.13	0.30	0.40	0.33	0.36	0.23	0.57	0.40
RSS005B		08-02-88	0.34	0.45	0.28	1.63	0.30	0.28	1.31	0.23	0.36	0.23	0.22	0.18	0.39	0.31
RSS005C		08-02-88	0.77	0.48	1.58	1.36	0.49	0.59	1.16	0.50	1.17	0.49	1.33	0.18	0.48	0.35
RSS005D		08-02-88	0.47	0.43	0.41	1.25	0.41	0.38	1.08	0.31	0.39	0.32	0.40	0.18	0.46	0.34
RSS007A		08-02-88	0.60	1.02	0.65	4.39	0.39	0.46	3.55	0.38	0.86	0.37	0.46	0.18	0.37	0.30
RSS0078		08-02-88	0.48	0.75	0.69	2.92	0.37	0.38	2.43	0.32	0.78	0.31	0.47	0.20	0.47	0.36
RSS007C		08-05-88	0.47	0.61	0.80	2.42	0.38	0.37	1.92	0.32	0.82	0.32	0.54	0.17	0.43	0.34
RSS007CD		08-08-88	0.49	0.55	0.90	2.55	0.35	0.38	1.85	0.29	0.90	0.33	0.64	0.18	0.44	0.35
RSS007D		08-05-88	0.37	0.55	0.31	1.85	0.33	0.31	1.58	0.26	0.41	0.26	0.26	0.18	0.40	0.32
RSS007E		08-05-88	0.40	0.49	0.37	1.57	0.35	0.33	1.35	0.29	0.40	0.26	0.31	0.19	0.42	0.34
RSS007F		08-05-88	0.37	0.54	0.39	1.67	0.34	0.31	1.46	0.28	0.46	0.25	0.31	0.20	0.43	0.35
RSS008A		08-02-88	1.08	0.53	0.45	1.96	0.45	0.75	1.55	0.59	0.49	0.66	0.41	0.18	0.40	0.32
RSS0088		08-02-88	0.37	0.51	0.29	1.77	0.32	0.30	1.46	0.26	0.40	0.24	0.24	0.21	0.43	0.35
RSS008C		08-02-88	0.38	0.50	0.33	1.75	0.34	0.32	1.44	0.27	0.40	0.26	0.29	0.20	0.47	0.36
RSS008D		08-08-88	2.46	0.60	0.47	2.40	0.52	1.53	1.81	1.16	0.58	1.62	0.47	0.20	0.38	0.30
RSS008E		08-08-88	0.39	0.34	0.31	1.22	0.32	0.31	0.95	0.23	0.34	0.27	0.27	0.24	0.59	0.43
RSS008F		08-08-88	0.35	0.40	0.27	1.57	0.31	0.28	1.16	0.22	0.36	0.24	0.23	0.19	0.51	0.39
RSS008G		08-08-88	0.32	0.32	0.30	1.23	0.28	0.26	0.94	0.21	0.33	0.23	0.27	0.16	0.37	0.29
RSS009A		08-02-88	0.40	0.41	0.35	1.44	0.35	0.33	1.17	0.27	0.37	0.29	0.30	0.18	0.47	0.36
RSS0098		08-02-88	0.40	0.40	0.30	1.31	0.33	0.32	1.05	0.26	0.35	0.26	0.25	0.16	0.39	0.32
RSS009C		08-02-88	0.40	0.46	0.38	1.55	0.37	0.33	1.28	0.29	0.41	0.28	0.35	0.19	0.43	0.34
RSS010A		08-02-88	0.46	0.54	0.41	1.80	0.40	0.38	1.57	0.32	0.44	0.29	0.34	0.24	0.59	0.44
RSS0108		08-02-88	0.38	0.46	0.29	1.44	0.34	0.32	1.25	0.27	0.34	0.25	0.24	0.19	0.48	0.39
RSS010C		08-02-88	0.66	1.04	1.05	3.68	0.47	0.52	3.26	0.47	1.05	0.39	0.80	0.20	0.40	0.34
RSS010D		08-02-88	0.53	0.62	0.66	2.35	0.40	0.41	1.85	0.34	0.63	0.34	0.60	0.18	0.41	0.33
RSS010E		08-02-88	0.49	0.51	0.40	1.76	0.39	0.39	1.39	0.30	0.44	0.32	0.35	0.31	0.77	0.52
RSS010F		08-02-88	0.41	0.44	0.32	1.52	0.37	0.34	1.23	0.28	0.38	0.28	0.26	0.20	0.44	0.34
RSS010G		08-02-88	0.42	0.64	0.34	2.47	0.36	0.34	1.97	0.27	0.50	0.28	0.30	0.25	0.51	0.38
RSS011A		08-03-88	0.37	0.59	0.46	2.51	0.32	0.29	1.85	0.25	0.58	0.26	0.41	0.18	0.40	0.31
RSS011B		08-02-88	0.36	0.35	0.27	1.28	0.31	0.30	0.96	0.24	0.35	0.25	0.23	0.18	0.44	0.32
RSS011C		08-03-88	0.36	0.38	0.28	1.43	0.31	0.29	1.11	0.23	0.35	0.25	0.23	0.18	0.44	0.36
RSS012A		08-03-88	0.34	0.40	0.27	1.55	0.30	0.27	1.19	0.22	0.36	0.24	0.22	0.21	0.46	0.37
RSS0128		08-03-88	0.41	0.39	0.30	1.37	0.35	0.32	1.09	0.27	0.36	0.28	0.27	0.19	0.46	0.36
RSS013A		08-03-88	0.37	0.35	0.28	1.21	0.30	0.28	0.94	0.23	0.32	0.25	0.25	0.19	0.44	0.33
RSS013B		08-03-88	0.38	0.36	0.31	1.29	0.33	0.31	1.00	0.24	0.36	0.27	0.26	0.22	0.61	0.43
RSS013C		08-03-88	0.40	0.45	0.33	1.69	0.34	0.32	1.33	0.25	0.40	0.28	0.28	0.19	0.38	0.31
RSS014A		08-03-88	0.36	0.36	0.31	1.19	0.30	0.29	0.96	0.23	0.34	0.25	0.26	0.18	0.42	0.33
RSS014B		08-03-88	0.39	0.46	0.39	1.70	0.33	0.31	1.24	0.26	0.42	0.26	0.32	0.17	0.34	0.28
RSS014C		08-03-88	0.39	0.53	0.31	2.05	0.35	0.32	1.59	0.25	0.42	0.27	0.25	0.20	0.33	0.27
RSS014D		08-03-88	0.37	0.42	0.31	1.51	0.31	0.29	1.23	0.24	0.36	0.25	0.26	0.19	0.40	0.32

SELECTED X-RAY FLUORESCENCE DATA FOR SILVER BOW CREEK SAMPLES

FILE	SITE	DATE	Index Values: Arsenic	Chromium	Copper	Iron	Krypton	Lead	Manganese	Mercury	Nickel	Selenium	Zinc	Barium (Fe source)	Cadmium (Fe source)	Silver (Fe source)
RSS014E		08-03-88	0.37	0.48	0.31	1.71	0.33	0.31	1.37	0.24	0.38	0.26	0.26	0.21	0.41	0.32
RSS014F		08-03-88	0.42	0.57	0.34	2.25	0.36	0.34	1.77	0.28	0.45	0.28	0.28	0.18	0.38	0.30
RSS015A		08-03-88	0.34	0.34	0.25	1.22	0.31	0.28	0.96	0.22	0.31	0.23	0.19	0.17	0.46	0.37
RSS015B		08-03-88	0.36	0.37	0.29	1.21	0.31	0.30	0.96	0.24	0.33	0.25	0.23	0.18	0.38	0.31
RSS016A		08-03-88	0.38	0.42	0.29	1.59	0.32	0.30	1.26	0.24	0.36	0.26	0.24	0.18	0.38	0.31
RSS016B		08-03-88	0.35	0.42	0.26	1.52	0.31	0.29	1.20	0.24	0.35	0.24	0.21	0.18	0.33	0.27
RSS016C		08-03-88	0.38	0.38	0.28	1.36	0.32	0.31	1.09	0.25	0.35	0.26	0.23	0.17	0.34	0.28
RSS017A		08-03-88	0.37	0.42	0.28	1.49	0.31	0.29	1.19	0.25	0.37	0.26	0.23	0.18	0.35	0.29
RSS017B		08-03-88	0.36	0.38	0.27	1.39	0.31	0.29	1.11	0.24	0.35	0.25	0.23	0.17	0.37	0.30
RSS017C		08-03-88	0.36	0.45	0.29	1.73	0.31	0.29	1.34	0.24	0.37	0.24	0.23	0.21	0.41	0.33
RSS017D		08-03-88	0.34	0.43	0.26	1.53	0.31	0.28	1.21	0.23	0.35	0.24	0.20	0.20	0.39	0.31
RSS018A		08-03-88	0.38	0.33	0.29	0.98	0.34	0.31	0.80	0.26	0.32	0.27	0.25	0.27	0.72	0.49
RSS018B		08-03-88	0.36	0.42	0.28	1.42	0.33	0.29	1.13	0.24	0.35	0.24	0.23	0.19	0.38	0.31
RSS019A		08-02-88	0.35	0.45	0.31	1.87	0.31	0.29	1.40	0.23	0.41	0.25	0.25	0.23	0.46	0.37
RSS019B		08-02-88	0.36	0.38	0.31	1.68	0.29	0.28	1.21	0.22	0.42	0.26	0.25	0.18	0.39	0.31
RSS019C		08-02-88	0.34	0.37	0.28	1.43	0.29	0.27	1.08	0.22	0.36	0.25	0.22	0.16	0.39	0.31
RSS019D		08-02-88	0.39	0.48	0.37	1.80	0.32	0.31	1.39	0.25	0.44	0.26	0.31	0.26	0.58	0.43
RSS020A		08-02-88	0.35	0.34	0.27	1.27	0.29	0.28	0.97	0.22	0.33	0.24	0.22	0.27	0.68	0.47
RSS020B		08-02-88	0.35	0.41	0.29	1.62	0.31	0.28	1.21	0.23	0.39	0.25	0.25	0.20	0.44	0.34
RSS020C		08-02-88	0.30	0.33	0.24	1.20	0.25	0.24	0.94	0.19	0.30	0.21	0.20	0.17	0.37	0.30
RSS021A		08-02-88	0.33	0.36	0.29	1.70	0.28	0.26	1.18	0.20	0.40	0.24	0.22	0.22	0.46	0.35
RSS021B		08-02-88	0.33	0.37	0.28	1.68	0.29	0.26	1.16	0.20	0.39	0.25	0.21	0.22	0.44	0.35
RSS021C		08-02-88	0.32	0.35	0.29	1.62	0.28	0.26	1.14	0.21	0.39	0.23	0.23	0.21	0.42	0.33
RSS022A		08-02-88	0.33	0.40	0.29	2.04	0.29	0.26	1.33	0.20	0.46	0.25	0.23	0.21	0.43	0.34
RSS022B		08-02-88	0.30	0.32	0.25	1.42	0.27	0.24	0.96	0.19	0.35	0.23	0.21	0.22	0.48	0.35
RSS022C		08-02-88	0.31	0.30	0.26	1.19	0.27	0.25	0.83	0.19	0.32	0.24	0.21	0.19	0.45	0.36
RSS023A		08-01-88	0.36	0.30	0.28	1.05	0.31	0.29	0.79	0.22	0.29	0.26	0.27	0.15	0.33	0.28
RSS023B		08-01-88	0.37	0.32	0.29	1.17	0.32	0.29	0.90	0.22	0.32	0.26	0.28	0.19	0.42	0.32
RSS023C		08-01-88	0.34	0.32	0.26	1.21	0.31	0.28	0.89	0.22	0.31	0.25	0.23	0.17	0.39	0.31
RSS024A		08-01-88	0.38	0.31	0.32	1.08	0.33	0.30	0.81	0.25	0.32	0.28	0.32	0.18	0.45	0.35
RSS024B		08-01-88	0.36	0.34	0.25	1.25	0.32	0.29	0.96	0.23	0.33	0.25	0.23	0.19	0.42	0.33
RSS025A		08-01-88	0.34	0.28	0.23	1.02	0.28	0.27	0.78	0.20	0.28	0.24	0.21	0.14	0.33	0.27
RSS025B		08-01-88	0.49	0.34	0.30	1.22	0.42	0.38	0.92	0.29	0.33	0.36	0.28	0.17	0.42	0.34
RSS026A		08-01-88	0.30	0.30	0.23	1.14	0.28	0.25	0.87	0.20	0.30	0.22	0.20	0.17	0.37	0.29
RSS026B		08-01-88	0.35	0.34	0.25	1.31	0.30	0.28	0.99	0.23	0.31	0.25	0.22	0.19	0.41	0.32
RSS026C		08-01-88	0.33	0.37	0.28	1.39	0.29	0.26	1.05	0.22	0.33	0.24	0.27	0.19	0.47	0.36
RSS026D		08-01-88	0.25	0.23	0.20	0.64	0.21	0.20	0.51	0.17	0.21	0.18	0.19	0.12	0.26	0.21
RSS026E		08-01-88	0.34	0.33	0.24	1.24	0.29	0.27	0.94	0.21	0.30	0.23	0.21	0.20	0.49	0.37
RSS027A		08-01-88	0.32	0.34	0.25	1.28	0.28	0.26	0.99	0.21	0.31	0.23	0.21	0.19	0.47	0.35
RSS027B		08-01-88	0.25	0.20	0.21	0.76	0.22	0.20	0.52	0.15	0.25	0.21	0.18	0.12	0.29	0.23
RSS027C		08-01-88	0.48	0.33	0.40	1.38	0.41	0.38	0.96	0.29	0.41	0.35	0.48	0.19	0.41	0.31
RSS028A		08-01-88	0.29	0.27	0.23	1.02	0.26	0.23	0.74	0.18	0.29	0.23	0.22	0.17	0.37	0.29
RSS028B		08-01-88	0.50	0.37	0.60	1.48	0.40	0.39	1.08	0.32	0.48	0.35	0.78	0.27	0.68	0.42
RSS028C		08-01-88	0.31	0.28	0.24	1.16	0.27	0.24	0.81	0.19	0.30	0.22	0.22	0.17	0.37	0.30
RSS028D		08-01-88	0.25	0.24	0.26	0.84	0.29	0.28	0.59	0.21	0.29	0.26	0.27	0.23	0.63	0.42
RSS029A		08-01-88	0.31	0.28	0.31	0.68	0.27	0.26	0.62	0.23	0.29	0.21	0.26	0.14	0.36	0.26
RSS029B		08-01-88	0.36	0.36	0.33	0.92	0.32	0.30	0.84	0.26	0.32	0.23	0.27	0.16	0.36	0.29
RSS029C		08-01-88	0.38	0.40	0.34	1.11	0.33	0.32	1.01	0.27	0.35	0.26	0.27	0.15	0.37	0.30
RSS029D		08-01-88	0.40	0.42	0.37	1.13	0.34	0.33	1.02	0.29	0.37	0.25	0.31	0.17	0.44	0.34
RSS029E		08-01-88	0.42	0.45	0.35	1.32	0.37	0.35	1.29	0.30	0.40	0.28	0.29	0.20	0.54	0.43

FILE	SITE	DATE	Index Values: Arsenic	Chromium	Copper	Iron	Krypton	Lead	Manganese	Mercury	Nickel	Selenium	Zinc	Barium (Fe source)	Cadmium (Fe source)	Silver (Fe source)
RSS030A		08-01-88	0.34	0.32	0.27	1.41	0.31	0.27	0.96	0.22	0.36	0.27	0.25	0.21	0.47	0.35
RSS030B		08-01-88	0.37	0.33	0.27	1.39	0.32	0.29	1.00	0.22	0.35	0.27	0.25	0.20	0.45	0.35
RSS030C		08-01-88	0.35	0.32	0.25	1.26	0.31	0.28	0.90	0.22	0.31	0.25	0.20	0.17	0.44	0.35
RSS031A		08-01-88	0.32	0.30	0.23	1.14	0.28	0.25	0.85	0.19	0.31	0.25	0.20	0.17	0.39	0.32
RSS031B		08-01-88	0.32	0.28	0.24	1.01	0.29	0.26	0.76	0.20	0.29	0.24	0.23	0.18	0.44	0.35
RSS031C		08-01-88	0.23	0.18	0.19	0.49	0.20	0.19	0.38	0.15	0.19	0.18	0.18	0.11	0.24	0.18
RSS032A		08-01-88	0.36	0.37	0.26	1.53	0.31	0.28	1.12	0.21	0.36	0.25	0.23	0.26	0.50	0.40
RSS032B		08-01-88	0.34	0.32	0.24	1.31	0.29	0.27	0.95	0.21	0.32	0.26	0.20	0.25	0.62	0.44
RSS032C		08-01-88	0.35	0.32	0.24	1.32	0.32	0.29	0.97	0.22	0.35	0.26	0.19	0.12	0.36	0.33
RSS033A		08-01-88	0.64	0.31	0.50	1.02	0.53	0.51	0.79	0.39	0.40	0.44	0.63	0.17	0.39	0.29
RSS033B		08-01-88	0.34	0.32	0.25	1.20	0.29	0.27	0.87	0.22	0.29	0.25	0.22	0.17	0.42	0.33
RSS033C		08-01-88	0.37	0.34	0.28	1.32	0.32	0.30	0.97	0.23	0.33	0.27	0.28	0.19	0.44	0.34
RSS034A		08-02-88	0.34	0.33	0.29	1.32	0.29	0.27	0.98	0.22	0.36	0.26	0.25	0.19	0.38	0.31
RSS034B		08-02-88	0.34	0.33	0.29	1.30	0.29	0.27	0.96	0.21	0.34	0.25	0.24	0.19	0.41	0.33
RSS034C		08-02-88	0.33	0.36	0.27	1.43	0.28	0.26	1.03	0.20	0.35	0.23	0.22	0.18	0.38	0.29
RSS035A		08-02-88	0.41	0.36	0.33	1.26	0.34	0.32	0.95	0.25	0.38	0.29	0.28	0.26	0.63	0.44
RSS035B		08-02-88	0.42	0.32	0.28	1.15	0.36	0.33	0.85	0.25	0.33	0.29	0.27	0.16	0.38	0.30
RSS035C		08-02-88	0.36	0.34	0.29	1.29	0.31	0.29	0.97	0.23	0.35	0.26	0.25	0.17	0.39	0.31
RSS036A		08-02-88	0.35	0.42	0.32	1.61	0.30	0.28	1.21	0.24	0.40	0.26	0.28	0.19	0.40	0.32
RSS036B		08-02-88	0.39	0.44	0.42	1.82	0.32	0.31	1.33	0.25	0.47	0.26	0.38	0.18	0.37	0.30
RSS036C		08-02-88	0.33	0.35	0.26	1.30	0.28	0.27	0.99	0.22	0.32	0.23	0.22	0.18	0.40	0.32
RSS036D		08-02-88	0.33	0.34	0.29	1.31	0.29	0.26	1.03	0.22	0.34	0.24	0.24	0.19	0.45	0.35
RSS037A		08-04-88	0.35	0.46	0.28	1.86	0.29	0.28	1.37	0.22	0.39	0.24	0.24	0.20	0.42	0.33
RSS037B		08-04-88	0.37	0.48	0.31	2.12	0.31	0.29	1.54	0.25	0.42	0.26	0.25	0.21	0.40	0.33
RSS037C		08-05-88	0.79	0.73	0.58	2.22	0.64	0.66	2.01	0.56	0.56	0.48	0.55	0.20	0.40	0.34
RSS037D		08-05-88	0.43	0.46	0.40	1.19	0.39	0.36	1.10	0.34	0.40	0.30	0.33	0.29	0.97	0.64
RSS038A		08-01-88	0.39	0.40	0.40	1.76	0.34	0.31	1.25	0.24	0.48	0.29	0.33	0.22	0.56	0.40
RSS038AD		08-01-88	0.43	0.51	0.44	1.93	0.37	0.35	1.53	0.29	0.48	0.30	0.35	0.23	0.58	0.42
RSS038B		08-01-88	0.44	0.72	0.38	2.91	0.39	0.36	2.33	0.30	0.56	0.31	0.31	0.25	0.59	0.43
RSS038C		08-01-88	0.36	0.31	0.30	0.89	0.34	0.31	0.75	0.26	0.31	0.25	0.24	0.15	0.47	0.39
RSS038D		08-01-88	0.38	0.46	0.33	1.42	0.34	0.32	1.20	0.27	0.38	0.25	0.27	0.19	0.49	0.38
RSS039A		08-01-88	0.42	0.40	0.38	1.23	0.35	0.34	1.03	0.28	0.38	0.28	0.31	0.17	0.42	0.35
RSS039B		08-01-88	0.40	0.44	0.32	1.35	0.34	0.33	1.17	0.29	0.36	0.26	0.25	0.18	0.41	0.34
RSS039C		08-01-88	0.41	0.48	0.35	1.39	0.35	0.33	1.21	0.29	0.40	0.27	0.28	0.18	0.42	0.34
RSS039D		08-01-88	0.39	0.47	0.32	1.39	0.34	0.32	1.23	0.29	0.37	0.26	0.26	0.18	0.39	0.32
RSS039E		08-01-88	0.42	0.47	0.36	1.32	0.37	0.35	1.16	0.30	0.39	0.29	0.29	0.17	0.41	0.36
RSS040A		08-01-88	0.34	0.37	0.25	1.43	0.29	0.27	1.07	0.21	0.33	0.24	0.21	0.21	0.46	0.35
RSS040B		08-01-88	0.39	0.35	0.31	1.31	0.32	0.31	1.00	0.24	0.37	0.27	0.27	0.16	0.41	0.34
RSS040C		08-01-88	0.33	0.32	0.37	1.18	0.26	0.26	0.90	0.22	0.34	0.23	0.40	0.17	0.37	0.28
RSS041A		08-01-88	0.33	0.32	0.26	1.19	0.29	0.27	0.91	0.21	0.30	0.23	0.24	0.18	0.41	0.33
RSS041B		08-01-88	0.37	0.37	0.28	1.31	0.32	0.30	0.98	0.23	0.34	0.26	0.23	0.16	0.40	0.32
RSS041C		08-01-88	0.37	0.36	0.29	1.36	0.33	0.30	1.02	0.24	0.37	0.27	0.24	0.22	0.60	0.46
RSS042A		08-01-88	0.40	0.40	0.33	1.46	0.32	0.32	1.11	0.25	0.39	0.29	0.27	0.19	0.40	0.33
RSS043A		08-01-88	0.41	0.39	0.32	1.48	0.34	0.33	1.14	0.26	0.39	0.28	0.28	0.19	0.46	0.37
RSS044A		08-01-88	0.37	0.35	0.30	1.23	0.31	0.29	0.97	0.23	0.36	0.25	0.26	0.18	0.41	0.33
RSS044B		08-01-88	0.35	0.37	0.29	1.36	0.30	0.28	1.03	0.23	0.35	0.25	0.24	0.20	0.39	0.31
RSS044C		08-01-88	0.35	0.38	0.29	1.35	0.29	0.28	1.06	0.22	0.36	0.25	0.23	0.19	0.39	0.32
RSS044D		08-01-88	0.35	0.39	0.30	1.42	0.29	0.28	1.12	0.22	0.36	0.24	0.24	0.19	0.39	0.33
RSS045A		08-01-88	0.35	0.37	0.29	1.31	0.29	0.28	0.99	0.23	0.35	0.24	0.24	0.20	0.40	0.33
RSS045B		08-01-88	0.37	0.38	0.31	1.43	0.30	0.29	1.10	0.24	0.38	0.26	0.26	0.19	0.39	0.33

SELECTED X-RAY FLUORESCENCE DATA FOR SILVER BOW CREEK SAMPLES

FILE	SITE	DATE	Index Values: Arsenic	Chromium	Copper	Iron	Krypton	Lead	Manganese	Mercury	Nickel	Selenium	Zinc	Barium (Fe source)	Cadmium (Fe source)	Silver (Fe source)
RSS045C		08-01-88	0.37	0.44	0.35	1.77	0.32	0.30	1.35	0.24	0.43	0.26	0.30	0.20	0.46	0.36
RSS046A		08-01-88	0.32	0.34	0.27	1.23	0.30	0.26	0.98	0.22	0.34	0.23	0.22	0.18	0.40	0.33
RSS047A		08-02-88	0.48	0.50	0.43	1.83	0.39	0.38	1.44	0.31	0.45	0.33	0.40	0.18	0.36	0.30
RSS048A		08-03-88	0.42	0.42	0.34	1.38	0.35	0.34	1.14	0.27	0.37	0.28	0.32	0.19	0.47	0.37
RSS048B		08-03-88	47.09	2.75	3.13	5.15	2.18	29.15	5.48	30.13	2.97	23.06	4.33	0.10	0.23	0.20
RSS049A		08-04-88	0.34	0.41	0.26	1.47	0.29	0.28	1.15	0.22	0.35	0.24	0.23	0.20	0.39	0.32
RSS050A		08-04-88	0.37	0.35	0.28	1.27	0.30	0.29	1.02	0.24	0.33	0.24	0.26	0.18	0.38	0.31
RSS051A		08-04-88	0.36	0.40	0.28	1.48	0.30	0.29	1.16	0.24	0.34	0.25	0.23	0.19	0.40	0.33
RSS065A		08-05-88	0.37	0.44	0.33	1.24	0.33	0.31	1.11	0.28	0.35	0.26	0.27	0.17	0.41	0.33
RSS065B		08-05-88	0.60	1.09	4.01	2.06	0.43	0.49	2.18	0.54	3.15	0.38	2.96	0.17	0.46	0.36
RSS065C		08-05-88	0.39	0.57	0.37	1.31	0.36	0.33	1.31	0.31	0.39	0.27	0.31	0.17	0.42	0.35
RSS066A		08-05-88	0.39	0.70	0.33	1.64	0.38	0.34	1.71	0.33	0.38	0.28	0.27	0.19	0.44	0.37
RSS066B		08-05-88	0.43	0.53	0.35	1.36	0.39	0.37	1.40	0.37	0.39	0.29	0.28	0.19	0.43	0.35

APPENDIX B

XRF SOIL SCREENING AND SOIL SAMPLING SITES, SITE LOCATION AND DESCRIPTION INFORMATION

XRF SOIL SCREENING AND SOIL SAMPLING SITES, LOCATION AND DESCRIPTION INFORMATION

NUMBER	DESCRIPTION	COMMENTS
1A	bare soil	1000' E. of Office, silver mill site
1B	sparse native grass	N. of office, wind trap area
1C	sparse native grass	N. of old school bldg.
1D	sparse native grass	S. of old school bldg.
1E	sparse native grass	S. of office bldg.
3A	bare soil	south of house
3B	bare soil	strawberry patch, west of house
4A	bare soil	south of house, play area in front yard
4B	bare soil	garden area
4C	bare soil	old garden, vegetables wouldn't grow, E of house
5A	bare area, native grass	west of building
5B	bare soil	fill dirt, SW of building
5C	bare tailings deposits	SSW of building, flood plain
5D	bare area in pasture	SE of building
7A	bare soil	RR ballast, mineralized fill material, E of tracks
7B	bare soil	RR ballast, mineralized fill material, between tracks
8A	bare soil	N of garage, insecticides used in area
8B	bare soil	garden, west of house
8C	slightly vegetated	SE corner of lot
8D	bare soil	NE corner of property
8E	bare soil	by wood pile
8F	bare soil	SW corner of property, outside back gate
8G	dead grass area	NW corner of front yard
9A	bare soil	play area, south (front) of house
9B	slightly vegetated	NW corner of lot
9C	bare area	SW corner of house
10A	bare soil	driveway west of shop
10B	bare soil	SW of shop
10C	bare soil	S of shop by RR tracks, drainage ditch
10D	bare tailings	S of shop, N bank of SBC
10E	bare soil	SW of shop, S of rental house, play area
10F	bare soil	N of white house
10G	bare soil	south of white house
10H	bare soil	NE corner red house
11A	bare soil	S of fence between house and garage
11B	bare soil	south of house
11C	bare soil	west of house
12A	bare soil	SW corner of house, play area
12B	bare soil	NE corner of garage
13A	bare soil	garden SE of house
13B	bare area	SE corner of house, N of driveway
13C	native vegetation	south of root cellar, SE of house
14A	bare soil	garden
14B	bare soil	NW corner of lot, outside of fence
14C	bare soil in native grass	north of lot, by RR tracks
14D	slightly vegetated	west of trailer
14E	bare soil in grass	play area by swing
14F	native grass	SW of trailer
15A	bare silty sand	15' below ground surface, parking lot cut
15B	sparse native grass	

XRF SOIL SCREENING LOCATION AND DESCRIPTION INFORMATION

NUMBER	DESCRIPTION	COMMENTS
16A	bare soil	garden
16B	native grass	west of house
16C	bare soil	east of house
17A	native grass	SE of new garage
17B	bare soil	east of trailer #3, play area dirt pile
17C	bare soil	south of trailer #8
17D	bare soil	N end of park, between access and main roads
18A	bare soil	east of house, play area
18B	bare soil	east of garage, S of driveway
19A	bare soil	front of house, by stairs
19B	slightly vegetated	SE of house
19C	bare soil	garden area, S. of house
19D	bare soil	garden, NW of trailer
20A	slightly vegetated	SW of house
20B	slightly vegetated	NW corner of property, 100' S. of freeway
20C	bare soil	garden, east of house
21A	slightly vegetated	SE corner of house
21B	bare soil	south of house, by barn
21C	sod	west of house
22A	bare soil	NE of house
22B	bare soil	excavation, 6' below surface, sandy silt
22C	slightly vegetated	west of house
23A	bare soil	SE corner of house
23B	bare soil	NE corner of garage
23C	bare soil	west of garage, next to alley
24A	bare soil	flower bed
24B	bare soil	west of house
25A	sod	south of house
25B	bare soil	west of house, south of sidewalk
26A	bare soil	flower bed, N of house
26B	bare soil	garden, NW corner of lot
26C	bare soil	SE corner of house
26D	sod	south of house
26E	bare soil	front of house, adjacent to Palmer Ave.
27A	bare soil	SW corner lot, adjacent to street
27B	sod	south side of house
27C	bare soil	NW corner house, by downspout
28A	sod	SW corner yard
28B	bare soil	SW corner of house near downspout, paint chips, roofing sand
28C	bare soil	flower bed, NW corner house
28D	bare soil	20' east of house
29A	garden area	south side of yard
29B	flower/garden area	west side of house
29C	sod	middle of back yard
29D	bare soil	SW corner of yard
29E	bare soil	west of yard, by driveway

XRF SOIL SCREENING LOCATION AND DESCRIPTION INFORMATION

NUMBER	DESCRIPTION	COMMENTS
30A	bare soil	front of house, N of sidewalk
30B	bare soil	south of garage
30C	slightly vegetated	east of house, adjacent to street
31A	bare soil	garden area
31B	bare soil	N side of house, by stairs
31C	sparce sod	east side of house
32A	bare soil	garden area
32B	Bare soil	NE corner of house
32C	sod	SW corner of house
33A	sod	SE of house
33B	bare soil	SW corner of house
33C	slightly vegetated	west of house. S of shed
34A	bare soil	SE corner of lot
34B	bare soil	west of garage
34C	bare soil	garden
35A	bare area in grass	E of house, play area by slide, former driveway
35B	sod	SW corner of house
35C	bare soil	south of house, by shed
36A	bare soil	field south of house
36B	bare soil	south of powerline, S of house
36C	bare soil	NW corner of house
36D	slightly vegetated	field N. of house
37A	sparse native grass	SW of Silverbow
37B	sparse native grass	N of town, S of RR Tracks
37C	sparse native grass	field south of town, south of RR Tracks
37D	bare soil	in town, SW of trailer between RR Tracks
38A	bare soil	south side of Ramsay School
38B	bare soil	west side of Ramsay School
38C	slightly vegetated	NW corner of Ramsay School
38D	slightly vegetated	north side of Ramsqy School
39A	bare soil	base of NE slide
39B	slightly vegetated	-
39C	bare soil	-
39D	slightly vegetated	-
39E	bare soil	SW corner, by backstop
40A	bare soil	SE corner lot, runoff area
40B	native grassland	south of garage
40C	bare soil	west of house by old bathtub
41A	bare soil	NW corner of house
41B	bare soil	garden
41C	bare soil	sandy play area
42A	native grassland, sagebrush	east of channel
43A	native grassland, sagebrush	west of channel
44A	native grassland	east of Post Office
44B	"	NE of Post Office
44C	"	north of Post Office
44D	bare soil	NW of Post Office
45A	sparse grass	N end of park
45B	native grassland	40' W of west central edge
45C	bare soil	S. end of park, slight swale

XRF SOIL SCREENING LOCATION AND DESCRIPTION INFORMATION

NUMBER	DESCRIPTION	COMMENTS
46A	native grassland	NE of Ramsay
47A	bare soil in native grass	500' SW of weigh station,
48A	bare soil	turnout N. of bridge
48B	bare soil	S. bank SBC, by wood retaining wall
49A	sparse native grass	midway between Ramsay Flats and road
50A	sparse native grass	west of Ramsay Flats
51A	sparse native grass	SW of Ramsay Flats
65A	sparse native grass	pasture south of house
65B	bare soil	south edge of pasture, salts on surface
65C	sparse native grass	west of house in pasture
66A	bare soil	south of house
66B	sparse native grass	west side of road, at end

APPENDIX C

SOILS LABORATORY ANALYTICAL DATA BASE

APPENDIX C: SOIL TOTAL METAL CONCENTRATIONS, SILVER BOW CREEK CERCLA SITE, PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT
04/25/89

TOTAL METALS: (1)

STATION	LOCATION	SAMPLE CODE	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	ITR Number	Aluminum	Antimony	Arsenic	Barium	Beryllium
SBC-SO-01D	Rocker Area	SE-G	N	08-05-88	0945	MHM708	11400	2.7 UN UJ	35.2	62.4	1.1
SBC-SO-04A	Rocker Area	SE-G	N	08-05-88	1230	MHM715	18200	8.2 BN J	36.3 D	297	1.1
SBC-SO-07A	Rocker Area	SE-G	N	08-05-88	1125	MHM713	25200	12.9 N J	1180	258	1.1
SBC-SO-07A	Rocker Area	SE-G	R	08-05-88	1135	MHM714	25300	2.7 UN UJ	872	260	1.4
SBC-SO-08A	Rocker Area	SE-G	N	08-05-88	1015	MHM710	7870	313 N J	24900	283	0.53 B
SBC-SO-09A	Rocker Area	SE-G	N	08-05-88	1005	MHM709	8230	5.0 BN J	30.2	213	0.60 B
SBC-SO-10C	Rocker Area	SE-G	N	08-05-88	1100	MHM712	14000	7.4 BN J	364	298	1.1
SBC-SO-10E	Rocker Area	SE-G	N	08-05-88	1030	MHM711	12100	2.6 UN UJ	48.9	179	1.2
SBC-SO-14B	Rocker Area	SE-G	N	08-05-88	0920	MHM706	13700	2.7 UN UJ	155	232	1.1
SBC-SO-14B	Rocker Area	SE-G	R	08-05-88	0925	MHM707	14200	6.6 BN J	145	241	0.88 B
SBC-SO-14E	Rocker Area	SE-G	N	08-05-88	0905	MHM705	16800	10.7 BN J	21.2 S	274	1.1
SBC-SO-15B	Rocker Area	SE-G	N	08-05-88	0830	MHM703	15400	6.7 BN J	37.0	177	0.51 B
SBC-SO-17D	Rocker Area	SE-G	N	08-05-88	0850	MHM704	21300	4.2 BN J	12.5 S	170	1.1
SBC-SO-19A	Nissler	SE-G	N	08-05-88	1340	MHM717	14400	3.8 BN J	21.9	225	0.45 B
SBC-SO-26A	Rocker Area	SE-G	N	08-03-88	1710	MHM701	14200	2.8 UN UJ	17.0 S	266	0.55 B
SBC-SO-26A	Rocker Area	SE-G	R	08-03-88	1720	MHM702	13900	2.8 UN UJ	13.6 S	235	0.55 B
SBC-SO-28B	Rocker Area	SE-G	N	08-03-88	1605	MHM465	14700	3.0 UN UJ	67.8	356	1.1
SBC-SO-31C	Rocker Area	SE-G	N	08-05-88	1420	MHM719	14400	5.0 BN J	25.1	465	0.74 B
SBC-SO-31C	Rocker Area	RINSEATE	WB	08-05-88	1430	MHM720	140 B	18.80 B	5.00 UN	100 BN J	4.20 UN
SBC-SO-31C	Rocker Area	DIW-G	BB	08-05-88	1440	MHM721	107 B	18.10 U	5.00 UN	99.50 BN J	4.20 UN
SBC-SO-31C	Rocker Area	SE-G	BFS	08-05-88	1450	MHM722	14500	2.6 UN UJ	17.3	95.9	0.84 B
SBC-SO-33A	Rocker Area	SE-G	N	08-05-88	1405	MHM718	15100	14.9 N J	50.9	308	0.50 B
SBC-SO-35A	Dawson	SE-G	N	08-03-88	1430	MHM460	10200	2.6 UN UJ	25.0	226	1.4
SBC-SO-37C	Silver Bow	SE-G	N	08-05-88	1320	MHM716	17000	7.6 BN J	107	249	0.94 B
SBC-SO-38A	Ramsay Area	SE-G	N	08-03-88	1530	MHM462	9720	2.6 UN UJ	124 S	350	0.44 B
SBC-SO-38A	Ramsay Area	SE-G	R	08-03-88	1540	MHM463	9780	2.6 UN UJ	80.4	358	0.72 B
SBC-SO-39E	Ramsay Area	SE-G	N	08-03-88	1515	MHM461	13000	3.5 BN J	143 S	226	0.50 B
SBC-SO-43A	Ramsay Area	SE-G	N	08-03-88	1630	MHM466	8350	3.1 BN J	105	154	0.47 B
SBC-SO-43A	Ramsay Area	SE-G	BFS	08-03-88	1640	MHM467	14800	2.6 UN UJ	20.7 S	96.2	0.53 B
SBC-SO-43A	Ramsay Area	RINSEATE	WB	08-03-88	1650	MHM468	147 B	18.10 U	5.00 UN	104 BN J	4.20 UN
SBC-SO-43A	Ramsay Area	DIW-G	BB	08-03-88	1700	MHM700	129 B	18.10 U	5.00 UN	97.10 BN J	4.20 UN
SBC-SO-45C	Ramsay Area	SE-G	N	08-03-88	1550	MHM464	24800	2.7 UN UJ	26.2	321	1.1
SBC-SO-65C	Miles Crossing	SE-G	N	08-05-88	1600	MHM723	13300	9.4 BN J	87.3	184	0.54 B

NOTES: 1) Units are mg/kg except for ITR #'s MHM-468, MHM-700, MHM-720, and MHM-721 which are in mg/L.

2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.

3) Data-quality analysis codes are defined as: < = less than detection, S = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits, Z = indicates value is anomalous based upon comparison with other data (data user code only).

4) Blank values indicate parameters not determined or not reported.

APPENDIX C: continued

04/25/89

METALS: continued

STATION	SAMPLE CODE	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
SBC-SO-01D	SE-G	N	08-05-88	0945	1.1	3640	4.4 J	3.9 B	40.4	18200	21.4 D J
SBC-SO-04A	SE-G	N	08-05-88	1250	3.9	7840	19.1	6.6 B	180	18300	874 D J
SBC-SO-07A	SE-G	N	08-05-88	1125	8.9	4500	22.7 E J	8.8 B	2050	61400	322 ED J
SBC-SO-07A	SE-G	R	08-05-88	1135	6.6	4310	21.0 E J	6.8 B	2020	59900	321 ED J
SBC-SO-08A	SE-G	N	08-05-88	1015	151	3470	17.9 E J	4.7 B	223	15400	576 ED J
SBC-SO-09A	SE-G	N	08-05-88	1005	3.0	6980	15.3	4.6 B	208	20200	435 D J
SBC-SO-10C	SE-G	N	08-05-88	1100	7.0	4760	14.7	8.9 B	2780	37800	601 D J
SBC-SO-10E	SE-G	N	08-05-88	1030	3.5	59700	74.7	5.8 B	216	19900	406 D J
SBC-SO-14B	SE-G	N	08-05-88	0920	3.0	2350	15.1	7.4 B	468	26100	192 D J
SBC-SO-14B	SE-G	R	08-05-88	0925	3.4	2350	16.8	7.3 B	465	27100	179 D J
SBC-SO-14E	SE-G	N	08-05-88	0905	1.6	7550	17.8	9.4 B	113	23700	103 D J
SBC-SO-15B	SE-G	N	08-05-88	0830	2.6	1380	13.1	9.4 B	120	15500	43.7 D J
SBC-SO-17D	SE-G	N	08-05-88	0850	0.84 B	7320	18.1	9.3 B	35.4	20900	16.4 D J
SBC-SO-19A	SE-G	N	08-05-88	1340	1.6	6210	17.1 E J	9.2 B	143	21200	326 ED J
SBC-SO-26A	SE-G	N	08-03-88	1710	2.3	9830	23.9 E J	6.7 B	81.9	15500	61.3 ED J
SBC-SO-26A	SE-G	R	08-03-88	1720	2.3	8700	22.0 E J	5.4 B	78.5	15600	50.6 ED J
SBC-SO-28B	SE-G	N	08-03-88	1605	23.3	33800	123 E J	7.8 B	510	15800	1510 ED J
SBC-SO-31C	SE-G	N	08-05-88	1420	4.3	5800	40.7 E J	8.5 B	124	14000	291 ED J
SBC-SO-31C	RINSEATE	WB	08-05-88	1430	1.00 UN	1640.40 U	3.10 B	6.80 U	15.80 U	30.20 B	12.00 LN R
SBC-SO-31C	DIW-G	BB	08-05-88	1440	1.00 UN	1640.40 U	3.60 B	6.80 U	15.80 U	37.40 B	13.60 SN J
SBC-SO-31C	SE-G	BFS	08-05-88	1450	3.6	22900	85.3 E J	12.3	97.7	31500	148 ED J
SBC-SO-33A	SE-G	N	08-05-88	1405	9.9	12000	35.6 E J	6.9 B	250	14300	406 ED J
SBC-SO-35A	SE-G	N	08-03-88	1430	3.0	19800	45.9 E J	7.7 B	135	15000	217 ED J
SBC-SO-37C	SE-G	N	08-05-88	1320	9.7	6530	38.2	10.6	269	32900	400 D J
SBC-SO-38A	SE-G	N	08-03-88	1530	2.9	18000	18.0 E J	4.6 B	394	24400	268 ED J
SBC-SO-38A	SE-G	R	08-03-88	1540	3.0	13700	20.1 E J	6.5 B	374	26700	191 ED J
SBC-SO-39E	SE-G	N	08-03-88	1515	4.9	3450	20.3 E J	5.1 B	237	15200	84.0 ED J
SBC-SO-43A	SE-G	N	08-03-88	1630	3.1	5980	20.2 E J	3.2 B	184	15000	92.6 ED J
SBC-SO-43A	SE-G	BFS	08-03-88	1640	3.1	23100	83.6 E J	11.3	97.2	32700	149 ED J
SBC-SO-43A	RINSEATE	WB	08-03-88	1650	4.30 BN J	1640.40 U	6.30 B	6.80 U	15.80 U	45.20 B	27.00 SN J
SBC-SO-43A	DIW-G	BB	08-03-88	1700	3.00 BN J	1640.40 U	2.50 U	6.80 U	15.80 U	33.50 B	3.40 UN J
SBC-SO-45C	SE-G	N	08-03-88	1550	6.5	13700	47.8 E J	10.8	245	23300	190 ED J
SBC-SO-65C	SE-G	N	08-05-88	1600	4.4	2930	20.9	6.6 B	232	13400	128 D J

NOTES: 1) Units are mg/kg except for ITR #'s MHM-468, MHM-700, MHM-720, and MHM-721 which are in ug/L.
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit. D = duplicate analysis was not within control limits. E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits, Z = indicates value is anomalous based upon comparison with other data (data user code only).
4) Blank values indicate parameters not determined or not reported.

APPENDIX C: continued

04/25/89

METALS: continued

STATION	SAMPLE CODE	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver
SBC-SO-01D	SE-G	N	08-05-88	0945	2650	290	0.10 U	1.7 U	3100	0.30 U	0.93 U
SBC-SO-04A	SE-G	N	08-05-88	1230	3900	1090	0.80	13.0	4230	0.30 U	1.3 B
SBC-SO-07A	SE-G	N	08-05-88	1125	4850	385 N J	0.87	1.5 U	7550	1.8 S	7.2
SBC-SO-07A	SE-G	R	08-05-88	1135	4870	393 N J	0.57	9.2	7310	2.1 S	6.2
SBC-SO-08A	SE-G	N	08-05-88	1015	2970	355 N J	17.7	12.8	2250	5.3 S	1.5 B
SBC-SO-09A	SE-G	N	08-05-88	1005	2290	842	1.1	6.8 B	2400	0.30 U	2.1
SBC-SO-10C	SE-G	N	08-05-88	1100	3810	803	1.1	10.2	4020	1.2 S	8.4
SBC-SO-10E	SE-G	N	08-05-88	1030	3940	434	0.23	7.0 B	3840	0.67 BW	0.93 U
SBC-SO-14B	SE-G	N	08-05-88	0920	2760	881	0.37	3.5 B	3150	0.37 B	2.9
SBC-SO-14B	SE-G	R	08-05-88	0925	2800	952	0.39	2.0 B	3230	0.37 B	2.9
SBC-SO-14E	SE-G	N	08-05-88	0905	4420	986	0.11 U	3.4 B	4060	0.32 U	0.99 U
SBC-SO-15B	SE-G	N	08-05-88	0830	2620	1020	0.10 U	1.7 U	2980	0.30 U	0.93 U
SBC-SO-17D	SE-G	N	08-05-88	0850	4270	524	0.10 U	10.1	3790	0.30 U	0.93 U
SBC-SO-19A	SE-G	N	08-05-88	1340	4310	689 N J	0.43	9.7	3990	0.31 U	1.1 B
SBC-SO-20A	SE-G	N	08-03-88	1710	4700	449 N J	0.11 U	10.6	3670	0.32 U	1.00 U
SBC-SO-20A	SE-G	R	08-03-88	1720	4730	454 N J	0.11 U	7.7 B	3500	0.40 B	1.1 B
SBC-SO-28B	SE-G	N	08-03-88	1605	4810	445 N J	0.83	15.4	3400	1.4	4.1
SBC-SO-31C	SE-G	N	08-05-88	1420	3970	493 N J	0.14 U	17.7	3160	0.60 BW	2.0 B
SBC-SO-31C	RINSEATE	WB	08-05-88	1430	500 U	2.40 U	0.20 U J	17.60 U	525.40 U	6.6 U	3.10 U
SBC-SO-31C	DIW-G	BB	08-05-88	1440	500 U	2.40 U	0.20 U J	17.60 U	525.40 U	4.70 B	3.10 U
SBC-SO-31C	SE-G	BFS	08-05-88	1450	8690	479 N J	1.5	33.4	2380	1.6 S	0.93 U
SBC-SO-33A	SE-G	N	08-05-88	1405	4100	583 N J	0.16	15.5	3830	0.78 B	2.1
SBC-SO-35A	SE-G	N	08-03-88	1430	2970	254 N J	0.10 U	14.6	3180	0.51 BW	2.0 B
SBC-SO-37C	SE-G	N	08-05-88	1320	3000	709	0.29	12.0 J	3170	0.45 B	4.0
SBC-SO-38A	SE-G	N	08-03-88	1530	3400	316 N J	0.10 U	4.1 B	2500	0.45 BW	2.6
SBC-SO-38A	SE-G	R	08-03-88	1540	3510	356 N J	0.10 U	10.4	2620	0.37 B	1.7 B
SBC-SO-39E	SE-G	N	08-03-88	1515	2780	399 N J	0.10 U	9.9 D	3850	0.37 B	2.1
SBC-SO-43A	SE-G	N	08-03-88	1630	1700	210 N J	0.10 U	2.4 B	1920	0.30 U	1.1 B
SBC-SO-43A	SE-G	BFS	08-03-88	1640	8910	485 N J	1.6	39.7	2240	0.75 B	0.93 U
SBC-SO-43A	RINSEATE	WB	08-03-88	1650	500 U	2.40 U	0.20 U J	17.60 U	525.40 U	4.70 B	3.10 U
SBC-SO-43A	DIW-G	BB	08-03-88	1700	500 U	2.40 U	0.20 U J	17.60 U	525.40 U	4.20 BW	3.10 U
SBC-SO-45C	SE-G	N	08-03-88	1550	6980	623 N J	0.10 U	19.7	5650	0.61 B	1.9 B
SBC-SO-65C	SE-G	N	08-05-88	1600	2960	490	0.20	7.9 B	4210	0.45 BW	0.93 U

NOTES: 1) Units are mg/kg except for ITR #'s MHM-468, MHM-700, MHM-720, and MHM-721 which are in ug/L.
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits, Z = indicates value is anomalous based upon comparison with other data (data user code only).
4) Blank values indicate parameters not determined or not reported.

APPENDIX C: continued

04/25/89

METALS: continued

STATION	SAMPLE CODE	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	Sodium	Thallium	Vanadium	Zinc	Comments
SBC-SD-01D	SE-G	N	08-05-88	0945	72.2 B	0.60 B	42.4	83.8 E J	
SBC-SD-04A	SE-G	N	08-05-88	1230	341 B	0.35 UW	36.6	683 E J	
SBC-SD-07A	SE-G	N	08-05-88	1125	1480	0.62 BW	59.3	395	
SBC-SD-07A	SE-G	R	08-05-88	1135	1400	0.53 BW	59.3	424	
SBC-SD-08A	SE-G	N	08-05-88	1015	178 B	0.51 B	28.2	449	
SBC-SD-09A	SE-G	N	08-05-88	1005	208 B	0.34 U	53.8	469 E J	
SBC-SD-10C	SE-G	N	08-05-88	1100	645 B	0.35 U	44.1	1520 E J	
SBC-SD-10E	SE-G	N	08-05-88	1030	651 B	0.34 U	108	511 E J	
SBC-SD-14B	SE-G	N	08-05-88	0920	141 B	0.34 U	59.9	345 E J	
SBC-SD-14B	SE-G	R	08-05-88	0925	153 B	0.34 U	64.0	343 E J	
SBC-SD-14E	SE-G	N	08-05-88	0905	256 B	0.37 U	58.7	300 E J	
SBC-SD-15B	SE-G	N	08-05-88	0830	233 B	0.34 U	34.3	139 E J	
SBC-SD-17D	SE-G	N	08-05-88	0850	206 B	0.35 U	51.3	71.4 E J	
SBC-SD-19A	SE-G	N	08-05-88	1340	515 B	0.35 UW	53.7	400	
SBC-SD-26A	SE-G	N	08-03-88	1710	382 B	0.37 U	36.0	232	
SBC-SD-26A	SE-G	R	08-03-88	1720	388 B	0.37 U	35.8	217	
SBC-SD-28B	SE-G	N	08-03-88	1605	539 B	0.48 B	80.0	2840	
SBC-SD-31C	SE-G	N	08-05-88	1420	409 B	0.46 UW	30.7	332	
SBC-SD-31C	RINSEATE	WB	08-05-88	1430	1570 B	4.60 UW	4.90 U	15.80 U	
SBC-SD-31C	DIW-G	BB	08-05-88	1440	1480 B	4.60 U	4.90 U	15.80 U	
SBC-SD-31C	SE-G	BFS	08-05-88	1450	252 B	0.34 UW	27.4	438	
SBC-SD-33A	SE-G	N	08-05-88	1405	367 B	0.36 UW	43.1	611	
SBC-SD-35A	SE-G	N	08-03-88	1430	285 B	0.51 BDW	50.0	374	
SBC-SD-37C	SE-G	N	08-05-88	1320	207 B	0.34 UW	91.7	817 E J	
SBC-SD-38A	SE-G	N	08-03-88	1530	454 B	0.34 U	54.9	681	
SBC-SD-38A	SE-G	R	08-03-88	1540	469 B	0.34 U	65.0	611	
SBC-SD-39E	SE-G	N	08-03-88	1515	179 B	0.34 U	39.1	243	
SBC-SD-43A	SE-G	N	08-03-88	1630	124 B	0.34 U	46.8	189	
SBC-SD-43A	SE-G	BFS	08-03-88	1640	178 B	0.60 B	26.8	420	
SBC-SD-43A	RINSEATE	WB	08-03-88	1650	1570 B	4.60 U	6.60 B	15.80 U	
SBC-SD-43A	DIW-G	BB	08-03-88	1700	1440 B	4.60 U	4.90 U	15.80 U	
SBC-SD-45C	SE-G	N	08-03-88	1550	376 B	0.43 B	63.3	483	
SBC-SD-65C	SE-G	N	08-05-88	1600	217 B	0.34 UW	26.1	310 E J	

NOTES: 1) Units are mg/kg except for ITR #'s MHM-468, MHM-700, MHM-720, and MHM-721 which are in ug/L.
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits, Z = indicates value is anomalous based upon comparison with other data (data user code only).
4) Blank values indicate parameters not determined or not reported.

APPENDIX D

GROUNDWATER QUALITY DATA BASE

APPENDIX D: GROUNDWATER QUALITY DATA BASE, SILVER BOW CREEK CERCLA SITE, PUBLIC HEALTH AND ENVIRONMENTAL ASSESSMENT

01/06/89

SAMPLE I.D.	SAMPLE TYPE	SAMPLE DATE	SAMPLE TIME	ITR NUMBER	STATIC WATER LEVEL (-FT)	TEMPERATURE (deg. C)	pH (s.u.)	Eh (mv)	SPECIFIC CONDUCTANCE (umhos/cm @ 25 deg.C)	DISSOLVED OXYGEN (mg/L)
SBC-GW-GS-01	N	08-19-88	0930	MHM724	3.05	10	7.1	+180	343	2.3
SBC-GW-GS-01	BFS	08-19-88	1000	MHM751						
SBC-GW-GS-03	BFS	08-19-88	1030	MHM752						
SBC-GW-GS-03	N	08-19-88	1300	MHM725	7.67	11	7.4	+210	482	7.9
SBC-GW-GS-03	R	08-19-88	1315	MHM726	7.67	12	7.4	+210	482	7.9
SBC-GW-GS-06	N	08-19-88	1530	MHM728	8.85	8	6.8	-30	1387	2.2
SBC-GW-GS-06	R	08-19-88	1600	MHM729	8.85	9	6.8	-50	1418	2.7
SBC-GW-GS-06	WB	08-19-88	1630	MHM730		29	6.2	+120	17	7.8
SBC-GW-GS-06	BB	08-19-88	1640	MHM731						
SBC-GW-TS-01	N	08-19-88	1430	MHM727	10.53	10	6.7	+175	620	4.8

NOTES: 1) Units are ug/L unless otherwise noted.
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits.
4) Blank values indicate parameters not determined or not reported.

APPENDIX D: continued

01/06/89

Dissolved Metals (1)

STATION	SAMPLE TYPE	SAMPLE CODE	SAMPLE DATE	SAMPLE TIME	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium
SBC-GW-GS-01	N	GW-G	08-19-88	0930	68.90 B J	18.10 U N	5.00 UW NJ	183 B N	4.20 U N	1.00 U	41400
SBC-GW-GS-01	BFS	GW-G	08-19-88	1000	342 J	150	87.80 S N	247 NJ	64.20 NJ	89.50 NJ	1640.40 U
SBC-GW-GS-03	BFS	GW-G	08-19-88	1030	358 J	141	95.90 S N	253 NJ	64.00 NJ	89.40 NJ	1640.40 U
SBC-GW-GS-03	N	GW-G	08-19-88	1300	92.60 B J	18.10 U	8.40 BW NJ	260 N	4.20 U NJ	1.60 B	40000
SBC-GW-GS-03	R	GW-G	08-19-88	1315	100 B J	19.30 B	10.60 N	257 NJ	4.20 U N	1.90 B NJ	39600
SBC-GW-GS-06	N	GW-G	08-19-88	1530	79.40 B J	36.60 B	15.10 N	124 B NJ	4.20 U N	4.10 B NJ	141000
SBC-GW-GS-06	R	GW-G	08-19-88	1600	36.30 B J	25.80 B	13.00 S N	88.50 B NJ	4.20 U N	5.90 NJ	123000
SBC-GW-GS-06	WB	GW-G	08-19-88	1630	100 B	26.80 B	5.00 UW N	104 B NJ	4.20 U N	1.00 U N	1640.40 U
SBC-GW-GS-06	BB	GW-G	08-19-88	1640	66.30 B	18.10 U	5.00 UW N	101 B NJ	4.20 U N	1.00 U N	1640.40 U
SBC-GW-TS-01	N	GW-G	08-19-88	1430	108 B J	18.10 U	5.00 U N	137 B NJ	4.20 U N	4.10 B NJ	65200

NOTES: 1) Units are ug/L unless otherwise noted.
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits, Z = indicates value is anomalous based upon comparison with other data (data user code only).
4) Blank values indicate parameters not determined or not reported.

APPENDIX D: continued

01/06/89

Dissolved Metals: continued

STATION	SAMPLE TYPE	SAMPLE CODE	SAMPLE DATE	SAMPLE TIME	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese
SBC-GW-GS-01	N	GW-G	08-19-88	0930	2.50 U	6.80 U	15.80 U	23.20 U	11.80 SD NJ	10200	671
SBC-GW-GS-01	BFS	GW-G	08-19-88	1000	134	203	252	127	75.40 D NJ	500 U	159
SBC-GW-GS-03	BFS	GW-G	08-19-88	1030	136	204	252	127	87.70 SD NJ	500 U	159
SBC-GW-GS-03	N	GW-G	08-19-88	1300	2.50 U	6.80 U	21.00 B	23.20 U	3.40 UWD NJ	6230	47.60
SBC-GW-GS-03	R	GW-G	08-19-88	1315	2.50 U	6.80 U	23.30 B	23.20 U	3.40 UWD NJ	6200	45.80
SBC-GW-GS-06	N	GW-G	08-19-88	1530	5.00 B	14.60 B	15.80 U	17900	4.60 BD NJ	34800	5370
SBC-GW-GS-06	R	GW-G	08-19-88	1600	2.50 U	12.90 B	15.80 U	13500	4.30 BD NJ	30800	5200
SBC-GW-GS-06	WB	GW-G	08-19-88	1630	3.90 B	6.80 U	15.80 U	23.20 U	3.40 UWD NJ	500 U	3.60 B
SBC-GW-GS-06	BB	GW-G	08-19-88	1640	2.50 U	6.80 U	15.80 U	23.20 U	3.40 UWD NJ	500 U	2.40 U
SBC-GW-TS-01	N	GW-G	08-19-88	1430	7.10 B	6.80 U	124	36.10 B	4.90 BD NJ	17400	13900

NOTES: 1) Units are ug/L unless otherwise noted.
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits, Z = indicates value is anomalous based upon comparison with other data (data user code only).
4) Blank values indicate parameters not determined or not reported.

APPENDIX D: continued

01/06/89

Dissolved Metals: continued

STATION	SAMPLE TYPE	SAMPLE CODE	SAMPLE DATE	SAMPLE TIME	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium
SBC-GW-GS-01	N	GW-G	08-19-88	0930	0.20 U N	17.60 U	4420 B	3.30 U	3.10 U	18600	4.60 UE J
SBC-GW-GS-01	BFS	GW-G	08-19-88	1000	3.7 J	381	525.40 U	52.90 S	12.60	1480 B	24.30
SBC-GW-GS-03	BFS	GW-G	08-19-88	1030	3.9 J	366	525.40 U	86.30 S	15.70	1700	75.90 S
SBC-GW-GS-03	N	GW-G	08-19-88	1300	0.20 U J	18.50 B	6200	3.30 U	3.10 U	58600	4.60 UW
SBC-GW-GS-03	R	GW-G	08-19-88	1315	0.20 U J	17.60 U	6190	3.30 U	3.10 U	58100	4.60 UW
SBC-GW-GS-06	N	GW-G	08-19-88	1530	0.20 U J	30.70 B	9180	9.90	3.10 U	136000	4.60 UW
SBC-GW-GS-06	R	GW-G	08-19-88	1600	0.20 U J	36.70 B	8740	13.90 S	3.10 U	156000	4.60 UW
SBC-GW-GS-06	WB	GW-G	08-19-88	1630	0.20 U J	20.40 B	525.40 U	3.30 U	3.10 U	1780 B	4.60 UW
SBC-GW-GS-06	BB	GW-G	08-19-88	1640	0.20 U J	17.60 U	525.40 U	3.30 UW	3.10 U	1420 B	4.60 UW
SBC-GW-TS-01	N	GW-G	08-19-88	1430	0.20 U J	50.30	5080	3.30 UW	3.10 U	32000	4.60 UW

NOTES: 1) Units are ug/L unless otherwise noted.
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits, Z = indicates value is anomalous based upon comparison with other data (data user code only).
4) Blank values indicate parameters not determined or not reported.

APPENDIX D: continued

01/06/89

Dissolved Metals: continued

STATION	SAMPLE TYPE	SAMPLE CODE	SAMPLE DATE	SAMPLE TIME	Vanadium	Zinc			Comments
SBC-GW-GS-01	N	GW-G	08-19-88	0930	4.90 U	34.10			
SBC-GW-GS-01	BFS	GW-G	08-19-88	1000	120	212			
SBC-GW-GS-03	BFS	GW-G	08-19-88	1030	122	204			
SBC-GW-GS-03	N	GW-G	08-19-88	1300	8.00 B	95.30			
SBC-GW-GS-03	R	GW-G	08-19-88	1315	7.30 B	91.30			
SBC-GW-GS-06	N	GW-G	08-19-88	1530	4.90 U	1730			
SBC-GW-GS-06	R	GW-G	08-19-88	1600	4.90 U	1560			
SBC-GW-GS-06	WB	GW-G	08-19-88	1630	5.50 B	15.80 U			
SBC-GW-GS-06	BB	GW-G	08-19-88	1640	4.90 U	15.80 U			
SBC-GW-TS-01	N	GW-G	08-19-88	1430	4.90 U	470			

NOTES: 1) Units are ug/L unless otherwise noted.
2) Sample types are defined as: N = natural sample, R = replicate, KB = Kimwipe blank, BFS = blind field standard, WB = water blank, BB = bottle blank.
3) Data-quality analysis codes are defined as: < = less than detection, B = value greater or equal to instrument detection limit but less than contract detection limit, D = duplicate analysis was not within control limits, E = value estimated or not reported due to interference, I = no laboratory spike was determined, J = value useful only as estimate because quality control criteria were not met, L = correlation coefficient for method of standard addition was < 0.995, M = duplicate furnace injections > 20 RPD, N = spike sample recovery was not within control limits, R = value unuseable because quality control criteria were not met, S = value determined by method of standard addition, U = element analyzed for but not detected (The instrument detection limit is reported.), UJ = detection limit value useful only as an estimate because quality control criteria were not met, W = post digestion spike for furnace AA was not within control limits, Z = indicates value is anomalous based upon comparison with other data (data user code only).
4) Blank values indicate parameters not determined or not reported.

APPENDIX E

DESCRIPTIONS OF SELECTED STUDIES INCLUDED IN LITERATURE REVIEW

Adriano. 1986. Trace Elements in the Terrestrial Environment

This text provides statistical information on the average concentrations of elements in granitic igneous rocks. This information was used directly in the present report.

Anaconda Minerals Company. 1987. Final Remedial Investigation Report, Mill Creek, Montana, Anaconda Smelter Superfund Site, First Operable Unit.

The remedial investigation of this site included collection of soils from three areas in Montana with similar geologic and physiographic characteristics to the Mill Creek site. Samples were from varying intervals between 0 and 25 inches deep, with most from the 0 to 2 inch zone. The samples were analyzed for several metals found at the Mill Creek site to identify appropriate background concentrations for the metals. The reported arithmetic means for the background samples are used in this report.

Coxe et al. 1983. Statistical Tables, Sample Locality Maps, and an Explanation of Data Sets for Samples from the Selway-Bitterroot Wilderness, Idaho County, Idaho, and Missoula and Ravalli Counties, Montana.

As part of a mineral evaluation of the Selway-Bitterroot Wilderness, stream sediment samples were collected by the United States Geological Survey. The study area is predominantly underlain by Cretaceous age granitic rocks of the Idaho Batholith. Collected stream sediment samples were screened to less than 80-mesh and then pulverized to pass a 170-mesh sieve before analysis. Analysis was by a semiquantitative spectrographic method.

The study provided two types of geometric means that are used in the present report. Except for manganese, all geometric means are calculated using a method presented by A.J. Cohen (see USGS Professional Paper 574-B)) for treating data with values below

detection and/or less than the detection limit. In the case of manganese, because one value was observed above detection levels, Cohens method was not applicable. For manganese then, the geometric mean is for all values occurring within the range of analytical determination. Due to the large sample population, and no values found below the detection limit, this method should compare favorably to Cohens method. It should be noted that the geometric means calculated by both methods compared quite closely for those data sets with few non-detected or less than detection values.

Ebens and Shacklette. 1982. Geochemistry of Some Rocks, Mine Spoils, Stream Sediments, Soils, Plants and Waters in the Western Energy Region of the Conterminous United States.

This report provided information on the geochemical characteristics of various media in regions of the western United States containing coal and oil shale reserves. In total, twenty five study areas were examined for 59 elements utilizing various analytical techniques.

Information pertaining to one of the twenty five study areas was utilized; Study No. 16 of the Northern Great Plains. This study included collecting and analyzing samples of A-horizon soil material in North Dakota, South Dakota, Wyoming, and Montana. The report provided geometric means for the element data, except for zinc which was given as an arithmetic mean.

EPA. 1987. Remedial Investigation of Soils, Vegetation, and Livestock for the East Helena Site (ASARCO), East Helena, Montana.

This study includes an investigation of soil contamination associated with emissions from the East Helena Smelter. For comparative purposes, background samples were collected from outside the project area but near to the Helena valley. At each sample site material was collected from the 0-4, 4-8, 8-15, 15-30 inch deep zone. Samples were

air-dried, and screened through a 9-mesh sieve. Atomic absorption and inductively coupled plasma emission methods were used for sample analysis.

For the present report, the geometric mean for metal background values of the 0-4 inch depth were utilized.

Gough et al. 1984. Chemical Analyses of Soils and Other Surficial Materials, Alaska.

This report presents chemical data on Alaskan soils to establish estimates of element concentrations in soils and other surficial materials. A total of 172 samples were collected on a varying grid pattern that included all of Alaska. Soil samples were collected from depths of 20 inches or less, depending on the thickness of soil present. Samples were dried at ambient temperature, crushed, and screened to pass a 200-mesh sieve. Chemical analysis was by inductively coupled argon plasma optical emission spectrometry, except for manganese which was analyzed by X-ray fluorescence spectroscopy.

The report did not contain a statistical analysis of the data. For the present report, arithmetic means were calculated for 35 samples selected from the total data set on a sequential basis.

Johns et al. 1981. Geochemical Soil Sampling in Southern Silver Bow and Northern Madison Counties, Montana.

This report summarizes a soil investigation of a mineralized area along the west flank of the Highland Mountains. The area contains lode and placer deposits. Samples were collected in various geologic terrains including areas underlain by the Boulder Batholith, Precambrian Belt Supergroup sedimentary rocks, Paleozoic sedimentary rocks, and Precambrian metamorphic rocks. Sampling consisted of

collecting C-horizon soil, or other basal soil material, at sites on a one-tenth mile spaced grid. A total of 10,508 samples were collected and analyzed for copper, lead, zinc, silver, gold, and molybdenum. Collected samples were oven-dried and screened to a 80-mesh fraction. Initial analysis of the samples was accomplished by utilizing pyrosulfate fusion and colorimetric methods. In order to obtain a more efficient and sensitive analysis, these methods were replaced early in the study by an atomic absorption method.

In the report geochemical threshold values were calculated for copper, lead, zinc, and silver from cumulative frequency plots using 20 percent of the sample population (collected samples). For the purposes of this report an arithmetic mean was determined by utilizing the 50 percent value for cumulative frequency plots of the various metal concentrations.

Kabata-Pendias and Pendias. 1984. Trace Elements in Soils and Plants.

This text reviews current geochemical knowledge of trace elements found in rocks and soils. In addition, the authors have modified the data presented by Shacklette and Boerngen (1984) by segregating the soils data by parent rock type. The statistical data provided in the text for soils overlying granites and gneisses are used in the present report.

McClernan. 1982. Lithogeochemical data from The Rochester Mining District, Madison County, Montana.

This study provides the raw field data collected in a mineralized area in the southern end of the Highland Mountains. The study area geology consists of Precambrian metamorphic rocks with vein type deposits containing sulfide mineralization. Rock chip samples were collected on a grid-type sampling plan. Samples were crushed, digested, and

analyzed by induction coupled plasma emission methods. For the present report, arithmetic means for the data were calculated and tabulated.

McClernan and Lawson. 1981. Geochemical Exploration of the Newlan Creek Area, Meagher County, Montana.

The study area for this report is located in the Little Belt Mountains. The geology of the area consists of a stratabound deposit of lead and silver hosted in Newland Creek limestone, a member of the Belt Supergroup. Soil sampling was conducted to determine the extent and nature of copper, lead, zinc and silver concentrations in the soil. Approximately 194 samples were collected on a 0.1 mile grid that covered an inactive mine and surrounding area. Sampling consisted of obtaining material from the C-soil horizon or other basal soil material. Collected samples were oven dried and screened through a 100-mesh sieve to collect a fine fraction for analysis. Analysis was by an atomic absorption method. Sampling also included the use of controls, blanks, and replicates at the 5 percent level.

The report provided arithmetic means for copper, lead and zinc concentrations that were used in the present report.

Mosier et al. 1981. Analysis of Rocks and Stream Sediment from the Magruder Corridor Roadless Area, Idaho County, Idaho.

This study presents chemical analyses of rock and stream sediment samples collected from an area partially underlain by granite of the Idaho batholith. For the present report, only data on Cretaceous-Tertiary age granitic rocks were selected from the data set for analysis. From this group of rocks every fifth sample was sequentially selected to form a representative subset for computing an arithmetic mean. Means were not calculated for several metals due to numerous non-detected or less than detection values.

Motooka et al. 1978. Analyses of Rock, Soils, Stream Sediments, and Heavy-Mineral Concentrates of the Elkhorn Wilderness, Montana.

This study presents a data summary of a geochemical investigation covering the Elkhorn Wilderness, Jefferson and Broadwater Counties, Montana. The area is predominantly underlain by volcanic rocks of the Elkhorn series that contain sulfide mineralization. The Elkhorn volcanics are considered an extrusive equivalent to the intrusives that comprise the Boulder Batholith. A total of 700 rock, 222 stream sediment, and 119 soil samples were collected and analyzed. Rock samples were crushed to approximately 0.25 inch (6 mm) and pulverized to 140-mesh. Stream sediments and soils were dried and screened to a 80-mesh fraction and then pulverized to 140-mesh. Samples were analyzed using a semiquantitative spectrographic method. An atomic absorption technique was also used for determining zinc concentrations.

The study provided no statistical analysis of the data. An arithmetic mean was calculated for use in the present report from a subset of samples selected on a sequential basis; 20 soil, 25 stream sediment and 80 rock samples were selected for computation. Means were not calculated for several metals due to numerous non-detected or less than detection values.

Rice and Ray. 1984. Floral & Faunal Survey & Toxic Metal Contamination Study of the Grant-Kohrs Ranch National Historic Site.

This study collected information on the nature and extent of metal contamination associated with the Clark Fork River at the Grant-Kohrs ranch site. As part of the study, information on background metal levels were obtained from a control site on the Blackfoot River. The sampling of this site was limited to the collection of one sample.

The sample was collected from the interval 0 to 25 cm deep. It was air dried and screened through a 9-mesh sieve. Analysis was conducted using atomic absorption methods. Analytical results of this sample are found in the present report.

Shacklette and Boerngen. 1984. Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States.

This study was conducted to provide information on the background concentrations of 50 elements in soils of the conterminous United States. Collection of the samples was on a 80 km (50 mile) grid. Soils were sampled at a depth of approximately 20 cm, oven dried and screened through a 9-mesh sieve. Chemical analysis of the samples for metals was by various methods, including spectrographic, atomic absorption, and x-ray fluorescence techniques. The study provided means and ranges of metal concentrations for the conterminous United States and western United States that were used in the present report.

Siems et al. 1982. Chemical Analyses of Minus-200 Mesh Stream Sediments of the Anaconda-Pintlar Wilderness, Beaverhead, Deerlodge, Granite, and Ravalli Counties, Montana.

This study was performed to assist in determining the mineral resource potential of the Anaconda-Pintlar Wilderness area. The region is primarily underlain by Cretaceous-Tertiary intrusive rocks of the Boulder and Idaho batholith and also Precambrian Belt Series strata and isolated areas of Cambrian age strata. The area has been extensively glaciated. A total of 272 stream sediment samples were collected, air dried and screened through a 200-mesh sieve. The fines were then analyzed by a semiquantitative spectrographic method for 31 elements. In addition, zinc was also analyzed for by an atomic absorption method.

The report did not provide statistical information on the data. For the present report, an arithmetic mean was calculated for 25 of the samples, selected on a sequential basis from the total data set. Means were not calculated for several of the elements due to a large number of non-detected and less than detection values in the data sets.

Van Eckhout, E.M. 1980. Utilizing the Geochemical Data from the National Uranium Resource Evaluation (NURE) Program: An Evaluation of the Butte Quadrangle, Montana.

Under the NURE program, stream sediment samples were collected in the Butte quadrangle, Montana to provide information on the mineral resources of the area. The quadrangle includes the Rocker and Ramsay areas. A total of 1370 samples were collected and screened through a 100-mesh sieve. Analysis of the fine fraction utilized X-ray fluorescence and neutron activation methods.

Statistical information on copper, lead, zinc, and manganese were presented in the report. Arithmetic means for the present report were determined from cumulative frequency curves, by observing the concentration reported at the 50 percent value.

Woessner W.W., et al, 1984. Final Report, Arsenic Source and Water Supply Remedial Action Study, Milltown, Montana.

This report provided several sources of information for evaluating and determining background metal concentrations for stream sediments of the Milltown Reservoir. These included published data for sediments of various lakes, recent lake sediments, ancient lake sediments, and a standard composition for shale. Also included was grab and core sample data from the Blackfoot arm of the reservoir. This part of the reservoir is considered largely unimpacted by metals contamination. A final set of background values was chosen, based primarily on the authors inspection of the data and intuition.

For the purposes of the present report, the grab sample data was deemed the most representative of actual background concentrations for the Blackfoot River, and therefore have been tabulated. These samples were collected from the upper 15 to 20 cm of sediment using a Peterson grab sampler.

APPENDIX F

QA/QC REPORT FORMS

QUALITY ASSURANCE STATEMENTS

Parameter:_____ Matrix:_____ Project:_____

Method:_____ Analysis Type:_____ Case No.:_____

ACCURACY

1. Using Blind Field Standard data, we are _____ % confident that _____ % of the data lie within _____ ± _____ % of the reported value.

2. Using Laboratory Spike Recovery data, we are _____ % confident that _____ % of the data lie within _____ ± _____ % of the reported value.

PRECISION

1. Using Blind Field Replicate data we are _____ % confident that _____ % of the data lie within ± _____ % of the reported value.

2. Using Laboratory Duplicate data, we are _____ % confident that _____ % of the data lie within ± _____ % of the reported value.

COMPLETENESS

For completeness, _____ of the samples were determined valid. this is _____ % of the collected samples and _____ % of the planned samples.

COMPARABILITY

During the field collection and laboratory analysis specified QA/QC practices, as outlined in the project Quality Assurance Project Plan (QAPP), were adhered to making data for this parameter comparable to previous investigations (yes/no). If no, reason(s) are stated below.

_____

_____

_____

_____

_____

_____

_____

_____

_____

REPRESENTATIVENESS

1. Fields blanks representing both external and cross-contamination were analyzed, showing a maximum value for each collection event and sample type for _____ of:

Collection Date	Maximum Blank Value	Blank Type

These values if above the instrument detection limit of _____ ug/l for _____ represent significant contamination for samples of a similar type collected on the specified date.

2. Laboratory prepared blanks, representing lab external contamination were reviewed showing a maximum contamination of _____ ug/l or _____ times above/below the IDL of _____ ug/l for _____. For this parameter contamination is significant / isn't significant / isn't known.

ACCURACY FORM I

Accuracy based on: **Recovery of Blind Field Standards**
Parameter:_____ Matrix:_____ Page____ of ____
Project:_____ Case No:_____

Standard = _____ Source: _____

Date Collected	CLP Number	EPA Tag #	Value	%R

Outlier Test Using Chauvenet's Criteria

Iteration 1:	Iteration 2:	Iteration 3:
$\hat{x}$ = _____	$\hat{x}$ = _____	$\hat{x}$ = _____
SD = _____	SD = _____	SD = _____
C = _____	C = _____	C = _____
Critical C = _____	Critical C = _____	Critical C = _____
Outlier = _____	Outlier = _____	Outlier = _____

Accuracy Calculations

Accuracy: _____ ± _____ %
Completeness: _____ / _____ ; _____ %
Bias detected: _____ yes _____ no
Bias adjustment: _____ /_____ = _____
Raw data adjusted: _____ yes _____ no

Confidence level: _____ %
t-value: _____

ACCURACY FORM II

Accuracy based on: Recovery of Laboratory Spikes
Parameter: _____ Matrix: _____ Page ____ of ____
Project: _____ Case No.: _____

Laboratory QC Report No.	CLP Number	EPA Tag #	Date Collected	Sample Type*	%R

* N = Natural sample, R = Replicate sample, BB = Bottle Blank, BFS = Blind Field Standard, WB = Water Blank.

Outlier Test Using Chauvenet's Criteria

Iteration 1:	Iteration 2:	Iteration 3:
$\hat{x}$ = _____	$\hat{x}$ = _____	$\hat{x}$ = _____
SD = _____	SD = _____	SD = _____
C = _____	C = _____	C = _____
Critical C = _____	Critical C = _____	Critical C = _____
Outlier = _____	Outlier = _____	Outlier = _____

Accuracy Calculations

Accuracy: _____ ± _____ %
Completeness: _____ / _____ ; _____ %
Bias detected: _____ yes _____ no
Bias adjustment: _____ /_____ = _____
Raw data adjusted: _____ yes _____ no

Confidence level: _____ %
t-value: _____

PRECISION FORM 1

Precision based on: **Blind Field Replicates**
Parameter: _____ Matrix: _____ Page ____ of ____
Project: _____ Case No.: _____

Date Collected	Field Sample			Field Replicate			% RPD	RSD (pair)
	CLP Number	EPA Tag #	Value	CLP Number	EPA Tag #	Value		

Dixon's Q-test for Outlying Observations

Iteration 1:	Iteration 2:	Iteration 3:
n = _____	n = _____	n = _____
Q = _____	Q = _____	Q = _____
Critical Q = _____	Critical Q = _____	Critical Q = _____
Outlier = _____	Outlier = _____	Outlier = _____

Precision Calculations

RSD collective = $\Sigma(\text{RSD(pair)})^2$ = _____ n = _____
RSD overall = $[(\text{RSD collective})/(\text{n-1 pairs})]^{1/2}$ = _____
t @ _____ % Confidence limit = _____ for n-1 degrees of freedom.

Precision = $[((t_{n-1})(\text{RSD overall}))/(\text{n-1 pairs})^{1/2}] \times 100$ = ± _____ %
Completeness: _____ / _____ ; _____ %

PRECISION FORM II

Precision based on: Laboratory Duplicates
Parameter: _____ Matrix: _____ Page ____ of ____
Project: _____ Case No.: _____

Laboratory QC Report No.	CLP Number	EPA Tag #	Date Collected	Sample Type*	Int. Value	Dup. Value	% RPD	RSD (pair)

* N = Natural sample, R = Replicate sample, BB = Bottle Blank, BFS = Blind Field Standard, WB = Water Blank.

Dixon's Q-test for Outlying Observations

Iteration 1:	Iteration 2:	Iteration 3:
n = _____	n = _____	n = _____
Q = _____	Q = _____	Q = _____
Critical Q = _____	Critical Q = _____	Critical Q = _____
Outlier = _____	Outlier = _____	Outlier = _____

Precision Calculations

RSD collective = $\Sigma(\text{RSD(pair)})^2$ = _____ n = _____
RSD overall = $[(\text{RSD collective})/(n\text{-}1 \text{ pairs})]^{1/2}$ = _____
t @ _____ % Confidence limit = _____ for n-1 degrees of freedom.

Precision = $[((t_{n-1})(\text{RSD overall}))/(n\text{-}1 \text{ pairs})^{1/2}] \times 100$ = ± _____ %
Completeness: _____ / _____ ; _____ %

COMPLETENESS FORM

Element: _____ Matrix: _____ Page ____ of ____

Project: _____ Case No.: _____

	Natural Samples	Field Replicates	Water Blanks	Bottle Blanks	Fields Standards	TOTAL
Number of Samples Proposed						
Number of Samples Collected						
Number of Valid Samples						
% valid/proposed						
% valid/collected						

REPRESENTATIVENESS (CONTAMINATION) FORM

Parameter: _____ Matrix: _____ Page ____ of ____
Project: _____ Case No.: _____

Field Blanks (External and Cross Contamination)

Coll. Date	Parameter	IDL:ug/l AA	IDL:ug/l ICP	Blank Type*	Matrix Type	Maximum Contamination CLP Number	Maximum Contamination EPA Tag #	Maximum Contamination Value	Times IDL**

Laboratory Preparation Blanks

Laboratory QC Report No.	Parameter	IDL:ug/l AA	IDL:ug/l ICP	Max. Contamination Prep. Blank Value	Times IDL**

* BB = Bottle Blank (External), WB = Water Blank (Cross Contamination)
** If value is greater than IDL then contamination is significant.

REGION VIII: SUMMARY OF DATA QUALITY ASSURANCE

guideline references are from Contract #787

Case No._____ Project No._____

Site_____

Contractor Laboratory_____

Data Reviewer_____ Date of Review_____

Sample Matrix_____

Sample No._____ _____ _____ _____ _____

_____ _____ _____ _____ _____

_____ _____ _____ _____ _____

_____ _____ _____ _____ _____

_____ _____ _____ _____ _____

_____ _____ _____ _____ _____

_____ _____ _____ _____ _____

( ) Data are acceptable for use

( ) Data are acceptable for use with qualifications noted on the following pages

( ) Data are preliminary-pending action or verification

( ) Data are unacceptable

Action required by DPO?

No_____ Yes_____ Following items require action_____

_____

_____

_____

_____

Action required by the Project Officer (PO)?

No_____ Yes_____

Our Findings

Inorganic Data Completeness Checklist

____ Inorganic analysis data (Form I)

____ Initial calibration and continuing calibration verification (Form IIA)

____ CRDL standard for AA and ICP (Form IIB)

____ Blanks (Form III)

____ ICP interference check sample (Form IV)

____ Spike sample recovery (Form VA)

____ Post digestion spike sample recovery (Form VB)

____ Duplicates (Form VI)

____ Laboratory control sample (Form VII)

____ Standard addition results (Form VIII)

____ ICP serial dilutions (Form IX)

____ Holding times (Form X)

____ Instrument detection limits-quarterly (Form XI)

____ ICP interelement correction factors-quarterly (Form II)

____ ICP linear ranges-quarterly (Form XIII)

____ Raw data for interference checks

____ Raw data for calibration standards

____ Raw data for blanks

____ Raw data for CRI and/or CRA

____ Raw data for samples

____ Raw data for duplicates

____ Raw data for spikes

____ Traffic reports

Contract Compliance

I. **Initial and Continuing Calibration Verification** (ICV and CCV) (guidelines pg. E-4, Form IIA)

1. Was instrument calibrated daily and each time it was set up?
   yes____ no____

2. Were instruments calibrated using 1 blank and several standards?
   yes____ no____

3. Were calibration verifications within 90-110%?
   yes____ no____

4. Were continuing calibrations run at 10% frequency?
   yes____ no____

5. Were the raw data correctly transcribed onto Form IIA?
   yes____ no____

Comments:

II. **CRDL Standards for ICP (CRI) and/or AA (CRA)** (guidelines pg. E-6, Form IIB)

1. For ICP analysis, were standards (CRI) @ 2X the CRDL or the IDL (whichever was greater) analyzed at the beginning and the end of each sample run, or at a minimum of twice/8 hour shift, whichever was more frequent?
   yes____ no____

2. For furnace AA analysis, were standards (CRA) analyzed at the beginning and the end of each sample run, or at a minimum of twice/8 hour shift, whichever was more frequent?
   yes____ no____

3. Were the CRI and/or CRA standards analyzed <u>after</u> the ICV?
   yes____ no____

4. Were these data reported on Form IIB?
   yes____ no____

5. Were the raw data correctly transcribed onto Form IIB?
   yes____ no____

Comments:

III. Blanks (guidelines pg. E-6, Form III)

1. Was the initial calibration blank (ICB) analyzed immediately after the initial calibration verification (ICV)?
   yes____ no____

2. Was a continuing calibration blank (CCB) analyzed immediately after each continuing calibration verification (CCV)?
   yes____ no____

3. Was a preparation blank (PB) analyzed at a frequency of at least 1 in 20 samples?
   yes____ no____ NA____

4. How many elements were detected above the CRDLs? ____ (if 0, go to question 5)

   4a. How many elements were detected in the blanks at greater than one-half the amount detected in any sample? ____

5. Were raw data correctly transcribed onto Form III?
   yes____ no____

Comments:

IV. ICP Interference Checks (ICS) (guidelines pg. E-7, Form IV)

1. Was the ICS analyzed twice per 8 hour shift?
   yes____ no____

2. Were ICSs analyzed before and after samples?
   yes____ no____

3. Was any massive interference detected?
   yes____ no____

4. Were the ICSs within ±20% mean value?
   yes____ no____

5. Were raw data correctly transcribed onto Form IV?
   yes____ no____

Comments:

V. **Spike Sample Analysis (S)** (guidelines pg. E-8, Form V)

1. Were spikes analyzed at a frequency of 1 in 20 samples?
   yes____ no____

2. Were spike recoveries correctly calculated?
   yes____ no____

$$\% \text{ recovery} = \frac{(SSR - SR)}{SA} \times 100$$

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added

3. Were spike recoveries within the range of 75-125%?
   yes____ no____

   3a. For recoveries outside this range, were associated data flagged 'N' by the laboratory on Forms I and V?
   yes____ no____ NA____

   (an exception is granted where the sample concentration is >4X the spike concentration)

4. Were raw data correctly transcribed onto Form V?
   yes____ no____

* Refer to page E-9 (SOW 787) for information regarding the amount of spike to be added for each analyte and for other information about the Spike Sample Analysis.

Comments:

VI. **Duplicates (D)** (guidelines pg. E-11, Form VI)

1. Were duplicates analyzed at a frequency of 1 in 20 samples?
   yes____ no____

2. Were RPDs correctly calculated?
   yes____ no____

$$RPD = \frac{S - D}{(S + D)/2} \times 100$$

S = Sample
D = Duplicate

3a. For sample concentrations >5X the CRDL, were RPDs ±20%? (limits of ±35% apply for soil/sediment/tailings samples)

yes____ no____ NA____

3b. For sample concentrations <5X the CRDL, did duplicate analysis results fall outside the control window of ± the CRDL?

yes____ no____ NA____

3c. Where the RPDs exceeded the control limits, were the data flagged '*' on Forms I and VI by the laboratory?

yes____ no____ NA____

4. Were raw data correctly transcribed onto Form VI?

yes____ no____

* Other Considerations:
-Field blanks cannot be used for duplicate analyses
-Duplicates must be analyzed for each analytical method

Comments:

VII. Laboratory Control Sample (LCS) Analysis (guideline pg. e-12, Form VII)

1. Was an LCS analyzed for every sample delivery group or batch of samples, whichever was more frequent?

yes____ no____

2. Were recoveries within the 80-120% limit?

yes____ no____

-if the recoveries were outside this range the analysis must be terminated, the problem corrected and the previous samples associated with that LCS redigested and reanalyzed.

3. Were the raw data correctly transcribed onto Form VII?

yes____ no____

Comments:

VIII. Furnace Atomic Absorption (AA) QC Analysis (guidelines pg.E- 14, Form VIII)

1. Does the raw data package contain absorbance values for two injections per sample, the average values and the relative standard deviation (RSD)?
   yes____ no____

2. For analyte concentrations > the CRDL, did the RSD for the duplicate injections agree within 20%? (if yes, go to question 3)
   yes____ no____

$$RSD = \frac{SD}{M} \times 100$$

SD = Standard Deviation of Duplicate Injections
M = Mean of Duplicate Injections

2a. Were samples that exceeded the 20% criteria reanalyzed?
   yes____ no____

2b. Did any reanalyzed samples exceed the 20% criteria?
   yes____ no____

2c. If yes, did the laboratory flag the data on Form I with an 'M'?
   yes____ no____

3. Was the recovery of the spike > 40%? (if yes, go to question 4).
   yes____ no____

3a. If no, was the sample diluted and rerun with another spike?
   yes_____ no_____

3b. If the spike recovery is still < 40% after rerun, did the lab flag the data "E" on Form I?
   yes_____ no_____

4. Was sample absorbance > 50% of spike absorbance?* (if yes, go to question 5).
   yes_____ no_____

*Spike absorbance = absorbance of spiked sample - absorbance of sample.

4a. For spike recoveries between 85 and 115%, were results reported to the IDL?

yes_____ no_____

$$RPD = \frac{(SSR - SR)}{SA} \times 100$$

SSR = Spike Sample Recovery
SR = Sample Result
SA = Spike Added

4b. For spike recoveries outside the 85 and 115% range, were results reported to the IDL and flagged with a 'W'?

yes_____ no_____

5. Was spike recovery between 85 and 115%? (if no, go to question 6)

yes_____ no_____

5a. Were results quantified from calibration curve and reported to IDL?

yes_____ no_____

6. Was an MSA at 50, 100 and 150% of the sample absorbance analyzed?

yes_____ no_____

6a. Was each MSA analysis identified in the raw data along with the slope, intercept and correlation coefficient?

yes_____ no_____

6b. Were these data correctly transcribed onto Form VIII?

yes_____ no_____

6c. Were correlation coefficients(r) > 0.995?

yes_____ no_____

6d. If no, were MSAs run once more?

yes_____ no_____

-If the correlation coefficients were still < 0.995, data on Form I must be from the run with the best 'r' and the data on Forms I and VII must be flagged with a '+'.

Were these criteria met?

yes_____ no_____

6e. Were all MSA obtained data marked with an 'S'or an S+ on Form I?

yes_____ no_____

Comments:

IX. ICP Serial Dilution (L) Analysis (guidelines pg. E-12, Form IX)

1. Was an ICP serial dilution performed on each group of samples of a similar matrix (i.e., soil, water) and concentration (i.e., low, high) or for each sample delivery group, whichever was more frequent?

   yes____ no____

2. For elements with concentrations >10X the CRDL, did any exceed the serial dilution results by more than 10%? (if no, skip questions 3 and 4)

   yes____ no____

$$\% \text{ difference} = \frac{I - S}{I} \times 100$$

I = Initial Sample Result
S = Serial Dilution Result (instrument reading X5)

3. Which elements had concentrations that exceeded the 10% criteria? _____

4. Did the laboratory flag these data with an 'E' on Form IX?

   yes____ no____

5. Were the raw data correctly transcribed onto Form IX?

   yes____ no____

Comments:

X. **Instrument Detection Limits (IDL)** (guidelines pg. E-13, Form XI)

1. Were IDLs reported for each analyzed element?
   yes____ no____

2. Were IDLs reported for each instrument used?
   yes____ no____

3. Did the IDLs meet the contract requirements? (refer to pg. E-13, SOW 787)
   yes____ no____

Comments:

XI. **Interelement Corrections for ICP** (guidelines pg. E-13, Form XII)

1. Were correction factors reported on Form XII?
   yes____ no____

Comments:

XII. **Linear Range Analysis (LRA)** (guidelines pg. E-14, Form XII)

1. Was a linear range verification standard analyzed?
   yes____ no____

2. Was the result within $\pm$5% of the true value?
   yes____ no____

Comments:

Holding Times

Limits: Metals - 6 months; Hg - 30 days; Cn - 28 days.

1. Verified date of sample receipt by laboratory_____
2. Date of preparation/analyses_____
3. Were holding times met? yes____ no____

Analyte	Matrix	Date Sampled	Prep Date	Holding Time	Holding Time Limit/Met?	